HUC 10290101, 10290102, 10290103, 10290104, 10290105, 10290106 – Osage River
Water body IDs: 1293
303(d) Listing: *Escherichia coli*

Total Maximum Daily Load

for

Osage River
Barton, Bates, Cass, Cedar, Dade, Greene, Lawrence, Polk, St. Clair, Vernon Counties

303(d) Listing: *Escherichia coli* Bacteria

Submitted: May 24, 2024
Approved: August 16, 2024

Prepared by: Water Protection Program, Watershed Protection Section

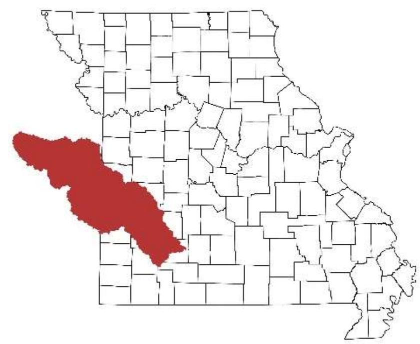
WATER BODY SUMMARY
Total Maximum Daily Loads (TMDL) for Osage River
303(d) Listing: *Escherichia coli (E. coli)* Bacteria

Name: Osage River

Location: Barton, Bates, Cass, Cedar, Dade, Greene, Lawrence, Polk, St. Clair, Vernon Counties

TMDL Development Priority: High

8-digit Hydrologic Unit Code (HUC):[1]
10290101 – Upper Marais des Cygnes
10290102 – Lower Marais des Cygnes
10290103 – Little Osage
10290104 – Marmaton
10290105 – Harry S. Truman Reservoir
10290106 – Sac


Location of watershed in Missouri

Water Body Identification (WBID) and Hydrologic Class:[2]
WBID 1293, Class P

Designated Uses:[3]
Irrigation
Livestock and wildlife protection
Human health protection
Warm water habitat (aquatic life)
Whole body contact recreation category A
Secondary contact recreation

Impaired Use:
Whole body contact recreation category A

Pollutant Identified on the 2022 303(d) List:
Escherichia coli (E. coli) (fecal indicator bacteria)

Identified Sources on the 2022 303(d) List:
Nonpoint sources

Length and Location of Impaired Segments:
WBID 1293 50.7 miles, from mouth to Section 33, Township 38N, Range 30W

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[1] Watersheds are delineated by the U.S. Geological Survey using a nationwide system based on surface hydrologic features. This system divides the country into 2,270 8-digit hydrologic units (USGS 2019). A hydrologic unit is a drainage area delineated to nest in a multilevel, hierarchical drainage system. A hydrologic unit code is the numerical identifier of a specific hydrologic unit consisting of a 2-digit sequence for each specific level within the delineation hierarchy (FGDC 2003).
[2] For hydrologic classes see 10 CSR 20-7.031(1)(E). Class P streams maintain permanent flow even in drought periods.
[3] For designated uses see 10 CSR 20-7.031(1)(F) and 10 CSR 20-7.031 Table H. Presumed uses are assigned per 10 CSR 20-7.031(2)(A) and (B) and are reflected in the Missouri Use Designation Dataset described at 10 CSR 20-7.031(2)(E).

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1. Introduction

In accordance with Section 303(d) of the federal Clean Water Act, the Missouri Department of Natural Resources is establishing this total maximum daily load (TMDL) to address fecal contamination as indicated by high concentrations of the fecal indicator bacteria, *Escherichia coli* (*E. coli*) bacteria, in the Osage River in Bates, St. Clair, and Vernon counties. This TMDL report addresses one water quality limited segment included on Missouri's 2022 303(d) List of Impaired Waters due to exceedances of Missouri's *E. coli* bacteria criterion for the protection of the whole body contact recreation (category A).[4] This listing was approved by the U.S. Environmental Protection Agency (EPA) on August 2, 2023.[5]

Section 303(d) of the federal Clean Water Act and Title 40 of the Code of Federal Regulations (CFR) Part 130 require states to develop TMDLs for waters that do not meet applicable water quality standards. Missouri's Water Quality Standards at Title 10 of the Code of State Regulations (CSR) Division 20 Chapter 7, Rule 7.031 consists of three major components: designated uses, water quality criteria to protect those uses, and an antidegradation policy. A TMDL is equal to the loading capacity of a water body for a specific pollutant and represents the maximum amount of a pollutant that a water body can assimilate and still attain and maintain water quality standards. The *E. coli* bacteria loading capacity for the water body is derived from the maximum *E. coli* concentration allowed by Missouri's Water Quality Standards and is translated to mass loads using stream flow under all recorded conditions. Once the loading capacity of a water body has been quantified, existing and future point sources and nonpoint sources are assessed for their potential to contribute the pollutants of concern. In accordance with 40 CFR 130.2, contributing point sources are assigned a portion of the available loading capacity as a wasteload allocation and nonpoint sources are assigned a load allocation. As required by the federal Clean Water Act in section 303(d)(1)(C), a margin of safety is also included. Margins of safety can be explicit (numeric) or implicit (qualitative) to account for any lack of knowledge concerning the relationship between pollutant loading and water quality, uncertainty associated with the model assumptions, or data inadequacies (40 CFR 130.7). The TMDL for any given pollutant is the sum of the wasteload allocation, the load allocation, and the margin of safety.

2. Watershed Description

Osage River watershed is located in western Missouri and eastern Kansas (Figure 1). The Osage River (WBID 1293) is formed by the confluence of the Marais des Cygnes and Little Osage Rivers in western Missouri, approximately 14 miles northeast of the City of Nevada on the Bates-Vernon County line. From this location, the Osage River flows east for approximately 50.7 miles before entering the Harry S. Truman Reservoir. The watershed includes an area of east-central Kansas (4,327 square miles) and a large portion of west-central and central Missouri (3,857 square miles), where it drains northwest areas of the Ozark Plateau. The Sac River enters the Osage River approximately 2 miles upstream of Harry S. Truman Reservoir and is the largest tributary in the eastern portion of the watershed with a drainage area of approximately 1,969 square miles. The total watershed area draining to WBID 1293 of the Osage River is composed of six 8-digit hydrologic unit code (HUC) subbasins and is approximately 8,184 square miles.

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[4] A water quality limited segment is any segment where it is known that water quality does not meet applicable water quality standards, or is not expected to meet applicable water quality standards, even after the application of the technology-based effluent limitations required by sections 301(b) and 306 of the federal Clean Water Act (40 CFR 130.2).

[5] The department maintains current and past 303(d) lists and corresponding assessment worksheets online at: dnr.mo.gov/water/what-were-doing/water-planning/quality-standards-impaired-waters-total-maximum-daily-loads/impaired-waters.

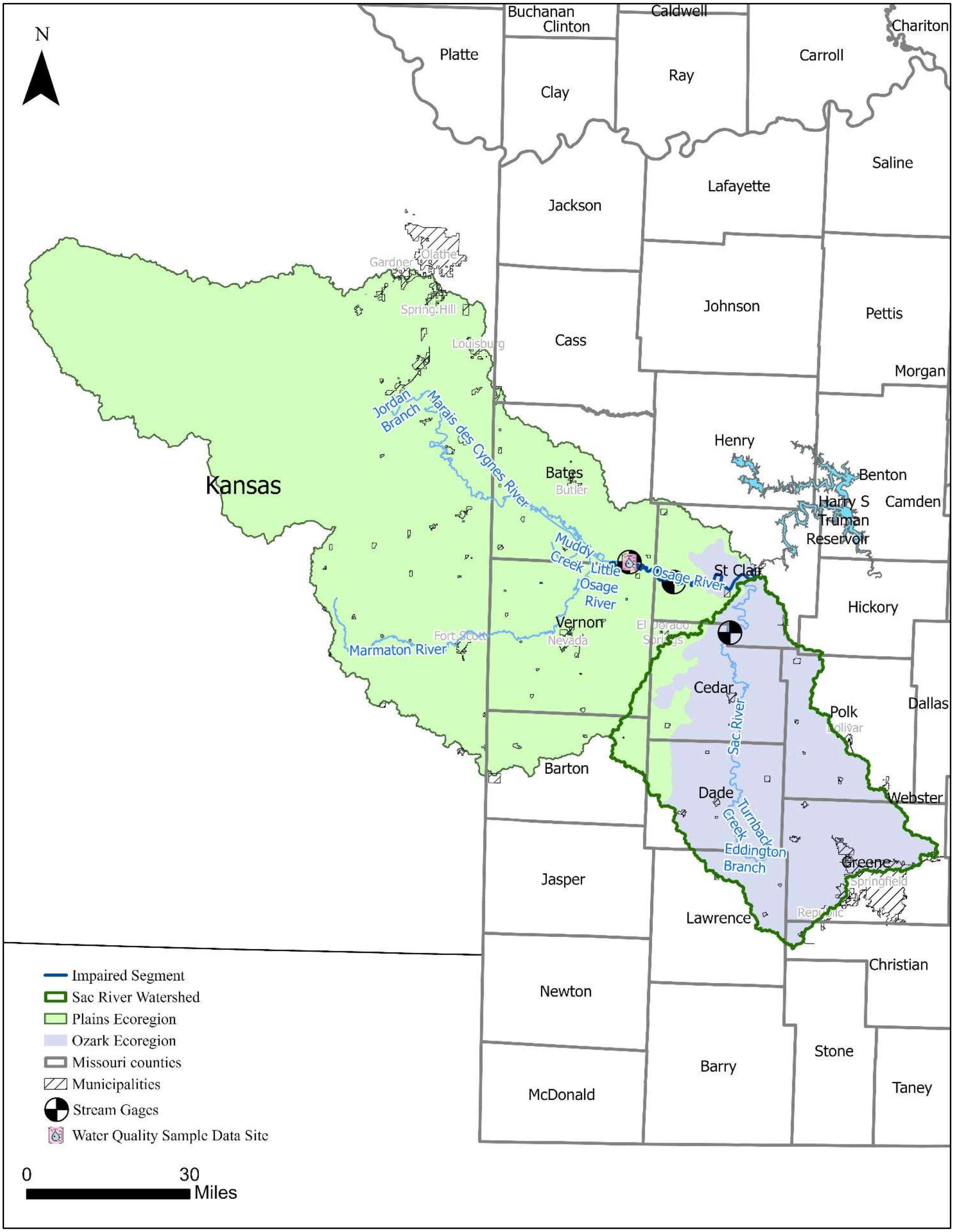

Figure 1. The Osage River watershed

2.1 Geology, Physiography, and Soils

The Osage River watershed is located within the Osage/South Grand ecological drainage unit (EDU), which primarily consists of eastern Kansas and west-central Missouri and includes Osage Plains in the western portion and Ozark Border in the eastern portion (MoRAP 2005). Ecological drainage units are groups of watersheds that have similar biota, geography, and climate characteristics (USGS 2009).

The Osage River watershed is also located in the Wooded Osage Plains EPA Level IV ecoregion. Ecoregion is defined in Missouri's Water Quality Standards at 10 CSR 20-7.031(1)(H) as "…areas of general similarity in ecosystems and in the type, quality, and quantity of environmental resources. They are designed to serve as a spatial framework for the research, assessment, management, and monitoring of ecosystems and ecosystem components. By recognizing spatial differences in the capacities and potentials of ecosystems, ecoregions stratify the environment by its probable response to disturbance." The Wooded Osage Plains ecoregion is an undulating plain with smooth, low, limestone, escarpments, and small areas of exposed bedrock. Pennsylvanian limestone, sandstone, and shale strata with differential erosion has produced a rolling topography, and the potential natural vegetation is a mosaic of oak-hickory woodland and bluestem prairie (Chapman et al. 2002).

Soils are categorized into hydrologic soil groups based on similar runoff potentials. Each hydrologic soil group indicates the rate at which water enters the soil profile under conditions of a bare, thoroughly wetted soil surface (NRCS 2009). This infiltration rate determines the quantity of precipitation that flows over land to water bodies as direct runoff. Group A soils have the highest rate of infiltration and the lowest runoff potential. Group D soils have the lowest rate of infiltration and highest runoff potential. Many wet soils fall into dual soil groups (e.g., Group C/D) due to the presence of a seasonal high water table that results in saturation to the soil surface. Dual hydrologic soil groups account for this condition by providing both the drained and undrained condition of the soil.[6] It should be noted that soil runoff potential is only one factor that determines the volume of runoff in a watershed. Impervious surfaces, vegetative cover, slope, rainfall intensity, and land use can significantly influence the potential for runoff regardless of the characteristics of the underlying soil. Figure 2 shows the distribution of hydrologic soil groups in the Osage River watershed. Table 1 provides a summary of the hydrologic soil groups in Missouri by area in square miles and relative percent.

[6] For the purpose of hydrologic soil group, adequately drained means that the seasonal high water table is kept at least 24 inches (60 centimeters) below the surface in a soil where it would be higher in a natural state (NRCS 2009).

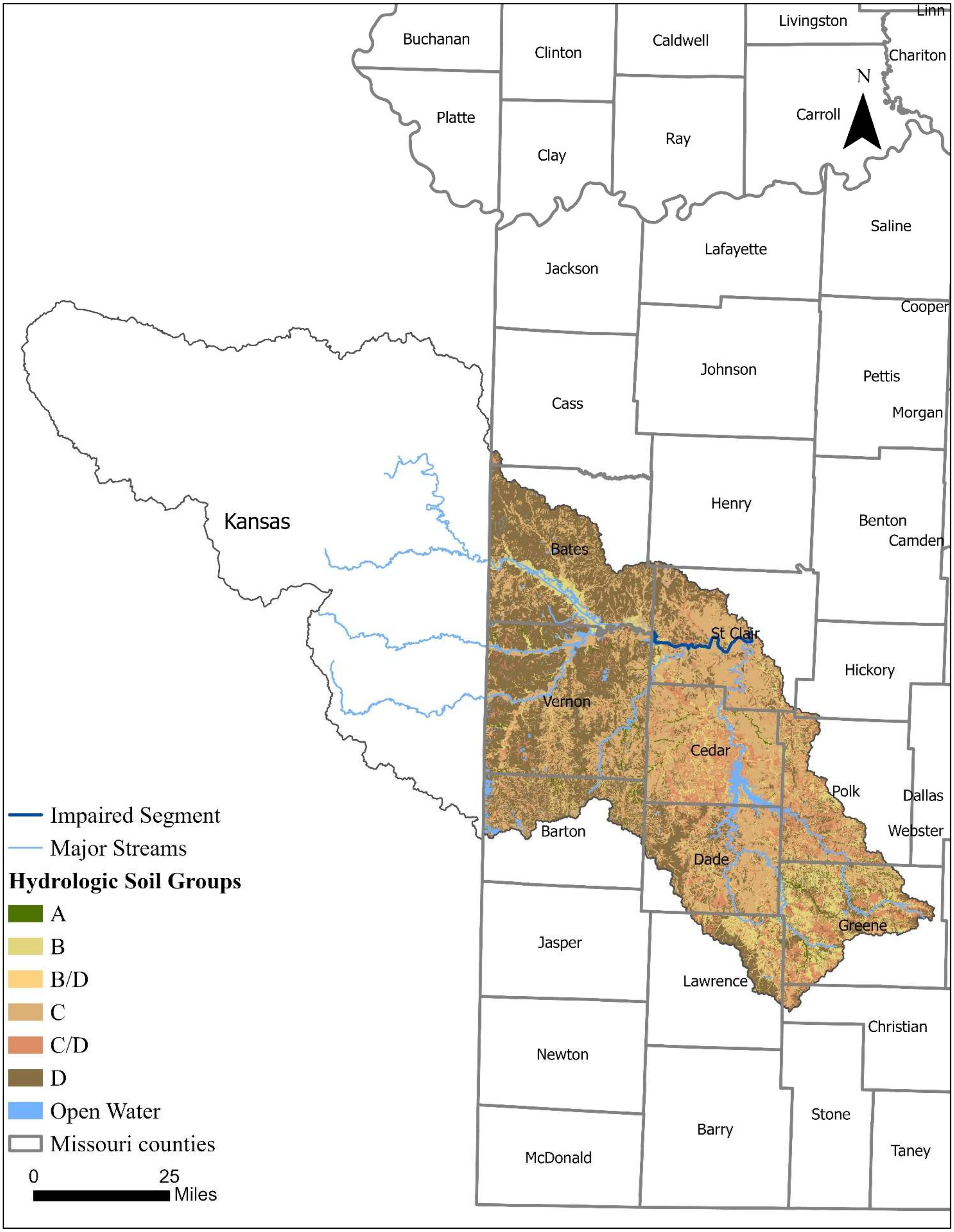

Figure 2. Hydrologic soil groups in the Osage River watershed in Missouri

Table 1. Hydrologic soil groups in the Osage River watershed in Missouri (NRCS 2020)

Hydrologic Soil Group	Area in the Watershed	
	Square miles	Percent
Group A	51.12	1.31%
Group B	438.36	11.23%
Dual Group B/D	21.81	0.56%
Group C	1,361.73	34.90%
Dual Group C/D	476.39	12.21%
Group D	1,465.19	37.55%
Open Water	87.41	2.24%
Total	3,902.01*	100.00%

*Due to rounding and data resolution, this value differs slightly from the calculated watershed area presented in Section 2.

2.2 Climate

The most recent climate data from a weather station in close proximity to the Osage River watershed were measured at the National Centers for Environmental Information El Dorado Springs Weather Station (USC00232511) in Cedar County. The climate normals were developed based on temperature and precipitation data collected at that station between 1991 and 2020 (NOAA 2020). Precipitation normals are especially important because they relate to stream flow and runoff events that influence pollutant loading. This information is provided to illustrate general climate conditions in the watershed and was not used to derive the TMDL loading targets or allocations. Table 2 presents the 30-year monthly climate normals from the El Dorado Springs Weather Station for precipitation and temperature. Figures 3 and 4 further summarize these data.

Table 2. 30-year monthly climate normals at the El Dorado Springs, MO weather station

Month	Precipitation Total	Minimum Temperature	Maximum Temperature
	inches	ºF	ºF
January	2.13	21.9	42.2
February	2.32	25.8	47.6
March	3.35	34.5	57.4
April	5.36	44.0	67.3
May	6.85	53.9	75.3
June	5.69	63.5	83.9
July	4.29	67.9	89.0
August	3.93	66.1	88.3
September	4.73	57.8	80.6
October	3.66	46.2	69.9
November	3.66	35.1	56.9
December	2.70	26.7	45.9
	Total	Average	Average
	48.67	45.3	67.0

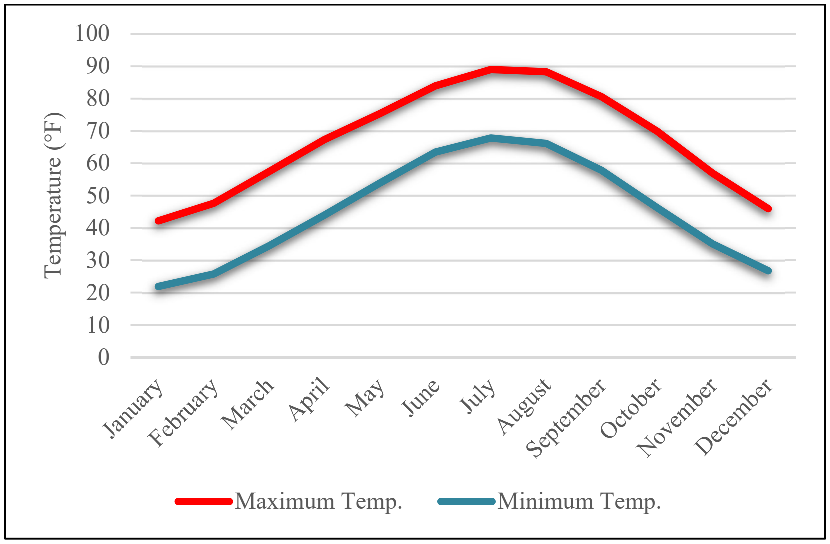

Figure 3. Monthly temperature normals at the El Dorado Springs, MO weather station

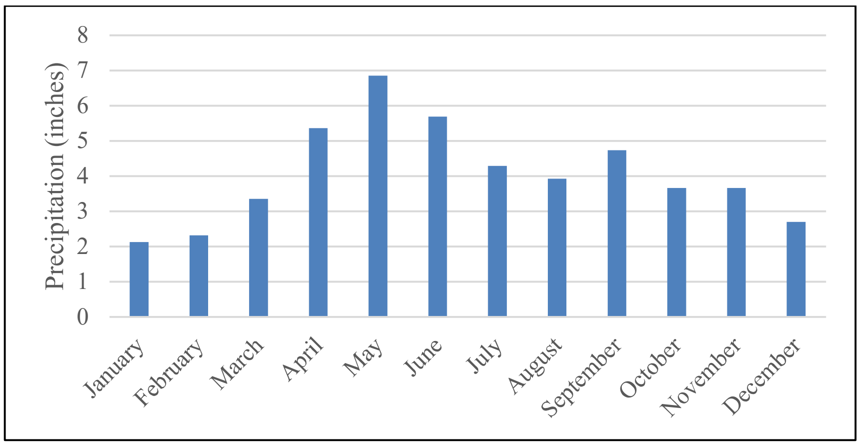

Figure 4. Monthly precipitation normals at the El Dorado Springs, MO weather station

2.3 Population

State and county population estimates are available from the U.S. Census Bureau's 2020 census and can be localized using census block data (U.S. Census Bureau 2020). Population estimates for the Osage River watershed were derived using geographic information system (GIS) software by overlaying the watershed boundary over a map of census blocks (Figure 5). Wherever the centroid of a census block fell within the watershed boundary, the entire population of the census block was included in the total. If the centroid of the census block was outside the boundary, the population of the entire block was excluded. The municipal population was estimated using a similar method whereby municipal areas were overlain on the map of census blocks. The rural population was calculated as the difference between the municipal population and the total population. The population that live in Missouri is fairly evenly divided with 46.5 percent residing in rural areas and 53.5 percent residing within municipal boundaries. As shown in Table 3, the population in the Osage River watershed increased by 10,259 people from 2000 to 2010 and by 574 people from 2010 to 2020.

Table 3. Population estimates for the Osage River watershed

2020 Total Population (includes Kansas)	Missouri Population Data								
	Municipal			Rural			Total		
	2000	2010	2020	2000	2010	2020	2000	2010	2020
214,862	61,167	64,704	64,088	67,427	74,149	75,339	128,594	138,853	139,427

U.S. Census Bureau data can also assist with identifying areas in the watershed with potential environmental justice concerns. EPA defines environmental justice as the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies (USEPA 2014a). Communities having environmental justice concerns may qualify for financial and strategic assistance for addressing environmental and public health issues. One example of financial assistance the department offers that may be available to communities having environmental justice concerns is Section 319 grant funding to address nonpoint sources. The department evaluates 319 grants on a number of criteria but gives higher priority for selection to proposed projects in disadvantaged communities. Additional grant and financial resource information is available on EPA's environmental justice website at www.epa.gov/environmentaljustice. This information is one approach that may be used to identify areas where there may be potential environmental justice concerns. The index is computed by the following equation:

$$Demographic\ index = \frac{\%\ People\ of\ Color + \%\ Low\ Income}{2}$$

The demographic data used in this analysis is from the U.S. Census Bureau and the index is derived from the Demographic Index used in EPA's web-based EJSCREEN tool. The EJSCREEN tool is available at https://www.epa.gov/ejscreen. This index is displayed as the state's percentile to compare areas more easily across the state. Within the watershed, census blocks demographic index range from the first percentile to 75th percentile. The block with the highest index is located in the northern portion of Springfield and is in the 75th percentile meaning that its demographic index is 75 percent higher than other census blocks within the state of Missouri.

Environmental justice encompasses a wide set of concerns and demographics. In addition to the Demographic Index, the EJSCREEN tool integrates 11 environmental pollution and 6 demographic indicators. Due to the numerous factors considered by the EJSCREEN tool, the department provides only generalized information in this TMDL. Local communities can identify and prioritize other environmental justice concerns for their watershed.

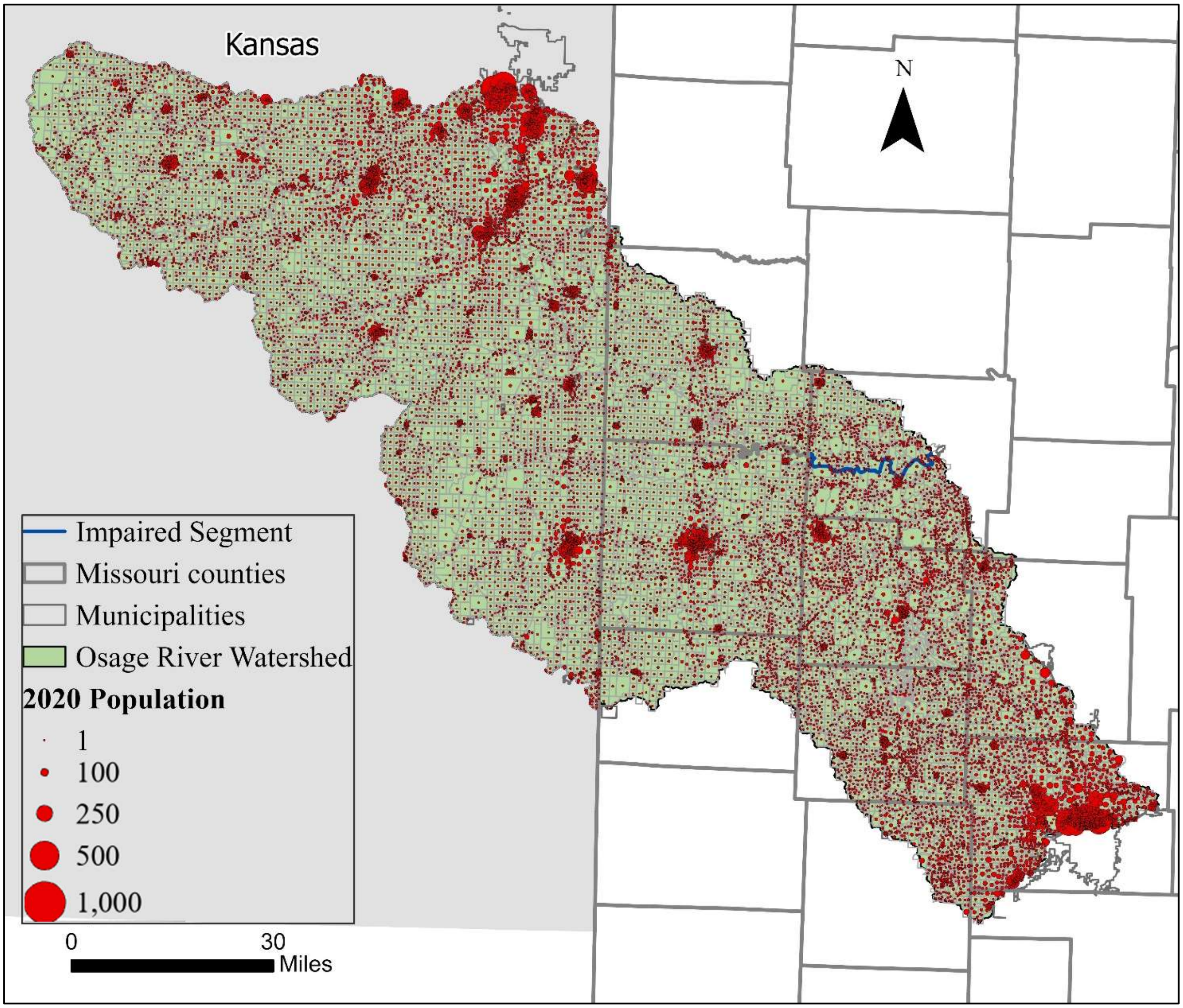

Figure 5. 2020 population in the Osage River watershed

2.4 Land Cover

A land cover analysis was completed using the 2019 National Land Cover Database published by the U.S. Geological Survey (USGS) (Dewitz 2019). Land cover types present in the Osage River watersheds are summarized in Table 4. Figure 6 depicts the distribution of the land cover types throughout the watershed. Agricultural land uses account for approximately 63.5 percent of the total watershed area while developed areas account for 5.4 percent of watershed area.

Table 4. Land cover in the Osage River watershed

Land Cover Type	Total Watershed		Missouri Only	
	Area Square Miles	Percent	Area Square Miles	Percent
Developed, High Intensity	11.97	0.15%	5.68	0.15%
Developed, Medium Intensity	46.48	0.57%	20.26	0.52%
Developed, Low Intensity	166.94	2.04%	67.94	1.74%
Developed, Open Space	219.37	2.68%	109.63	2.81%

Barren Land	9.79	0.12%	5.35	0.14%
Cultivated Crops	1,571.49	19.20%	613.11	15.71%
Hay and Pasture	3,628.01	44.32%	1,809.25	46.36%
Shrub and Herbaceous	515.65	6.30%	31.58	0.81%
Forest	1,677.97	20.50%	1,001.51	25.67%
Wetlands	202.21	2.47%	163.44	4.19%
Open Water	135.89	1.66%	74.46	1.91%
Totals	8,185.76*	100.00%	3,902.20*	100.00%

*Due to rounding and data resolution, these values differ slightly from the calculated watershed area.

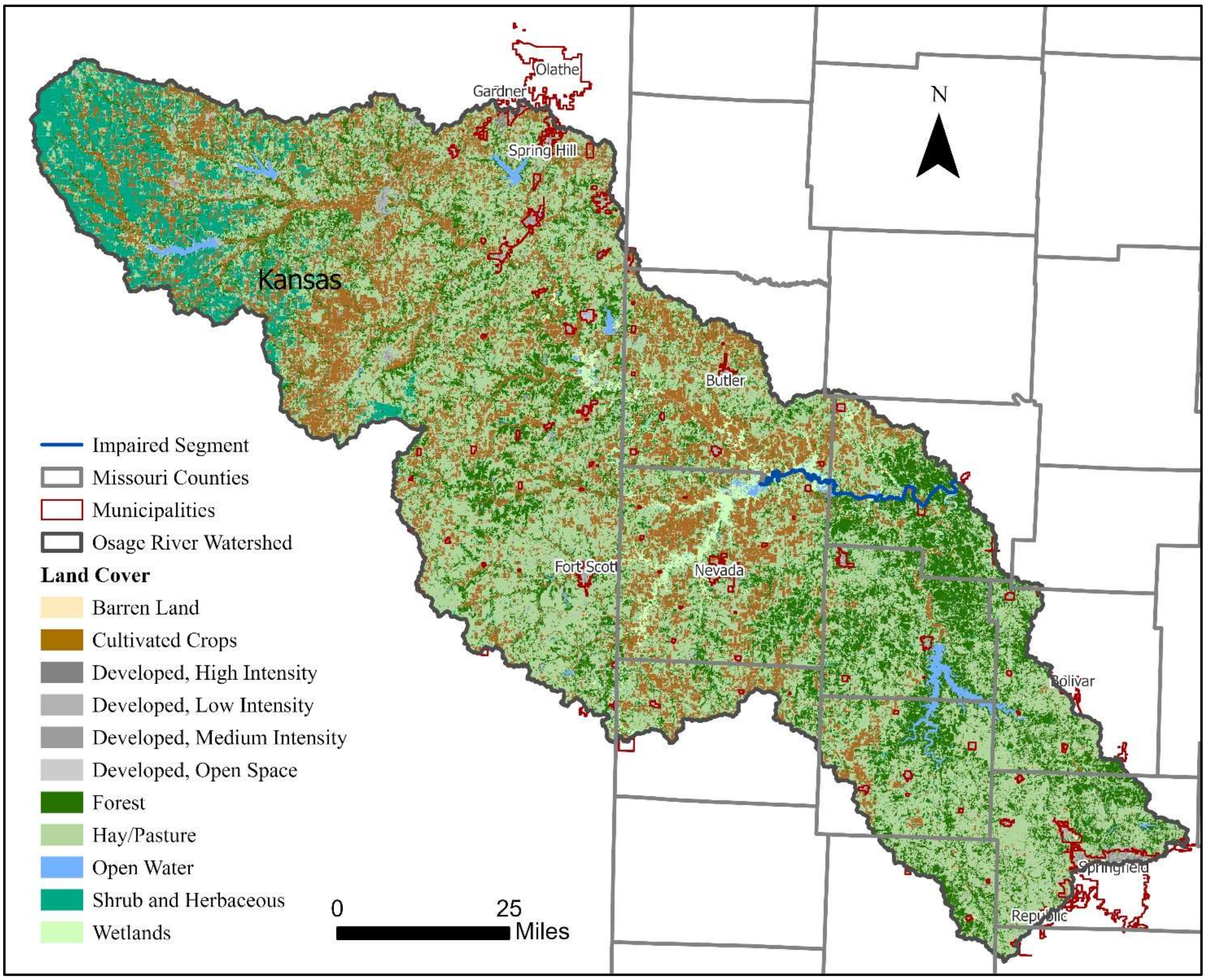

Figure 6. Land cover in the Osage River watershed

3. Applicable Water Quality Standards

TMDLs identify the maximum pollutant load that a water body can assimilate and still attain and maintain water quality standards. Water quality standards are therefore central to the TMDL development process. Under the federal Clean Water Act, every state must adopt water quality standards to protect, maintain, and restore the quality of the nation's surface waters (U.S. Code Title

33, Chapter 26, Subchapter III). Water quality standards consist of three major components: designated uses, water quality criteria, and an antidegradation policy. In accordance with federal regulations at 40 CFR 131.10, Missouri's Water Quality Standards for each individual water body also provide for the attainment and maintenance of water quality in any downstream waters. Revising existing water quality standards is not within the purview of TMDL development. If future water quality monitoring demonstrates that existing water quality standards are not protective of individual water bodies or downstream uses, new water quality standards can be proposed in accordance with the guidance provided in EPA's Water Quality Standards Handbook.[7]

3.1 Designated Uses

Missouri's Water Quality Standards at 10 CSR 20-7.031(1)(F) defines designated uses that are assigned to individual water bodies in accordance with 10 CSR 20-7.031(2) and are listed in 10 CSR 20-7.031, Table G (Lakes) and Table H (Streams). Missouri's Water Quality Standards designate the following uses to the Osage River:

- Irrigation
- Livestock and wildlife protection
- Human health protection
- Warm water habitat (aquatic life)
- Whole body contact recreation category A
- Secondary contact recreation

The whole body contact recreation category A designated use of Osage River is impaired due to high *E. coli* bacteria concentrations. Whole body contact recreation includes activities that involve direct human contact with waters of the state to the point of complete body submergence (10 CFR 20-7.031(1)(F)2.A.). During whole body contact activities, such as swimming, accidental ingestion of the water may occur and there is direct contact to sensitive body organs, such as the eyes, ears, and nose. Whole body contact category A applies to waters that have been established by the property owner as public swimming areas and waters with documented existing whole body contact recreation uses by the public (10 CSR 20-7.031(1)(F)2.A.(I)). Secondary contact recreation, which includes activities such as boating, fishing, and wading, are activities that may result in contact with the water that is either incidental or accidental and the probability of ingesting appreciable quantities of water is minimal (10 CSR 20-7.031(1)(F)2.B.). The secondary contact recreation use is not impaired in the Osage River.

3.2 Water Quality Criteria

Water quality criteria represent a level of water quality that supports and protects particular designated uses. Water quality criteria are expressed as specific numeric criteria and as general narrative statements. Missouri's Water Quality Standards (10 CSR 20-7.031(4) and (5)) establish general criteria applicable to all waters of the state at all times and specific criteria applicable to waters contained in 10 CSR 20-7.031, Tables G and H. Specific numeric *E. coli* bacteria criteria are given in Missouri's Water Quality Standards at 10 CSR 20-7.031(5)(C) and Table A1. For whole body contact recreation category A waters, *E. coli* concentrations during the recreational season (April through October) shall not exceed the geometric mean of 126 colony forming units (cfu) per 100 milliliters (mL) of water. This criterion is also protective of the secondary contact recreational use.

[7] https://www.epa.gov/wqs-tech/water-quality-standards-handbook

3.3 Antidegradation Policy

Missouri's Water Quality Standards include the EPA "three-tiered" approach to antidegradation and may be found at 10 CSR 20-7.031(3).

Tier 1 – Protects public health, existing instream water uses, and a level of water quality necessary to maintain and protect existing uses. Tier 1 provides the absolute floor of water quality for all waters of the United States. Existing instream water uses are those uses that were attained on or after November 28, 1975, the date of EPA's first water quality standards regulations related to existing uses.

Tier 2 – Protects and maintains the existing level of water quality where it is better than applicable water quality criteria. Before water quality in Tier 2 waters can be lowered, there must be an antidegradation review consisting of: (1) a finding that it is necessary to accommodate important economic and social development in the area where the waters are located; (2) full satisfaction of all intergovernmental coordination and public participation provisions; and (3) assurance that the highest statutory and regulatory requirements for point sources and best management practices for nonpoint sources are achieved. Furthermore, water quality may not be lowered to less than the level necessary to fully protect the "fishable/swimmable" uses and other existing uses.

Tier 3 – Protects the quality of outstanding national and state resource waters. Such waters are identified in 10 CSR 20-7.031 Tables D and E. There may be no new or increased discharges to these waters and no new or increased discharges to tributaries of these waters that would result in lower water quality.

Waters in which a pollutant is at, near, or exceeds the water quality criteria are considered in Tier 1 status for that pollutant. Therefore, the antidegradation goal for the Osage River is to restore water quality to levels that meet water quality standards.

4. Defining the Problem

E. coli are bacteria found in the intestines of humans and warm-blooded animals and are used as indicators of potential fecal contamination and risk of pathogen-induced illness to humans. In accordance with Missouri's 2022 Listing Methodology Document, the whole body contact recreation category A designated use for the Osage River is impaired because the geometric means of *E. coli* samples collected during the recreational season were greater than 126 cfu/100 mL in the most recent three years having available data with five or more samples.[8] Sufficient data consistent with the assessment methodology are available to support this listing as summarized in Table 5 and Figure 7. As shown, sufficient data for assessment were available in 2017, 2018, and 2019. *E. coli* concentrations exceeded the geometric mean of 126 cfu/100 mL during the recreational season in the Osage River in 2017 and 2019.

Individual *E. coli* measurements are provided in Appendix A, Table A-2, to illustrate the nature of the impairment, but were not used in the calculation of TMDL loading capacities or allocations.

[8] Listing Methodology documents are available online at https://dnr.mo.gov/document-search/methodology-development-2022-section-303d-list-missouri

Individual measurements may be used to estimate pollutant reduction targets, to target implementation activities, and to select appropriate best management practices (BMPs). Estimated reduction targets for the Osage River are presented in a supplemental TMDL implementation strategies document available online at: dnr.mo.gov/water/what-were-doing/water-planning/quality-standards-impaired-waters-total-maximum-daily-loads/tmdls.

Table 5. Summary of available recreational season *E. coli* data for the Osage River[9]

Recreation Season	Number of Samples	Minimum (cfu/100 mL)	Maximum (cfu/100 mL)	Geometric Mean* (cfu/100 mL)
2014	5	50	7,400	398
2015	5	30	2,900	440
2016	5	1	900	79
2017	5	27	8,700	377
2018	7	9	320	96
2019	5	30	2,200	213
2020	4	77	580	162

* Although geometric means are presented for all years of available data, only years with a minimum of five samples were used for assessment purposes.

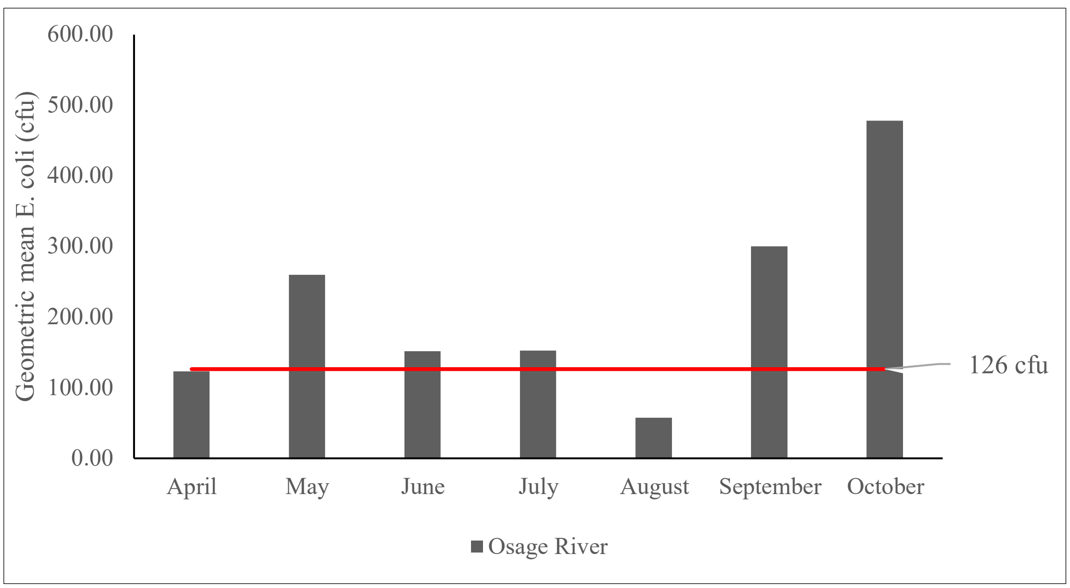

Figure 7. Geometric means for *E. coli* by month from 2014-2020

5. Source Inventory and Assessment

Point (typically regulated) and nonpoint (typically unregulated) sources may contribute to the elevated *E. coli* concentrations in Osage River. The following source inventory and assessment identifies and characterizes known, suspected, and potential sources of bacteria loading to the Osage River. Sources of bacteria loading are identified and quantified to the extent that information is available.

[9] *E. coli* data may be reported in units of most probably number (MPN) or colony forming units (cfu) depending upon the analysis method used. Data reported as cfu is an actual count of bacteria colonies, whereas MPN is a statistical approximation. Although differences may exist, they are often used interchangeably. For simplicity, and to maintain consistency with Missouri Water Quality Standards, all *E. coli* data in this TMDL are presented in units of cfu regardless of the methodology used.

5.1 Point Sources

Point sources are defined by Section 644.016(16) of the Missouri Clean Water Law and are regulated puruant to the National Pollutant Discharge Elimination System through the Missouri State Operating Permit program.[10] A point source is defined as "any discernible, confined, and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are or may be discharged. Point source does not include agricultural stormwater discharges and return flows from irrigated agriculture." Based on this definition, point sources include domestic wastewater treatment facilities, industrial and commercial facilities, concentrated animal feeding operations (CAFOs), MS4s, and stormwater discharges from industrial areas and construction sites. Illicit straight pipe discharges are also point sources but are illegal and therefore unpermitted. Pollutant loading from point sources is typically most evident during low-flow conditions when stormwater influences are lower or nonexistent. In Kansas, point sources are regulated by the Kansas Department of Health and Environment and are presented in this document for informational purposes only. The locations of permitted point sources in the Osage River watershed are presented in Figure 8.[11] Facility types and their expected contributions to the impaired stream are described individually in the following sections.

[10] The Missouri State Operating Permit program is Missouri's program for administering the federal National Pollutant Discharge Elimination System (NPDES). Generally, the Clean Water Act requires all point sources that discharge pollutants to waters of the United States to obtain a NPDES permit. Issued and proposed operating permits are available online at: dnr.mo.gov/water/business-industry-other-entities/permits-certification-engineering-fees.

[11] Each marker on the map represents an outfall. There may be multiple outfalls per facility.

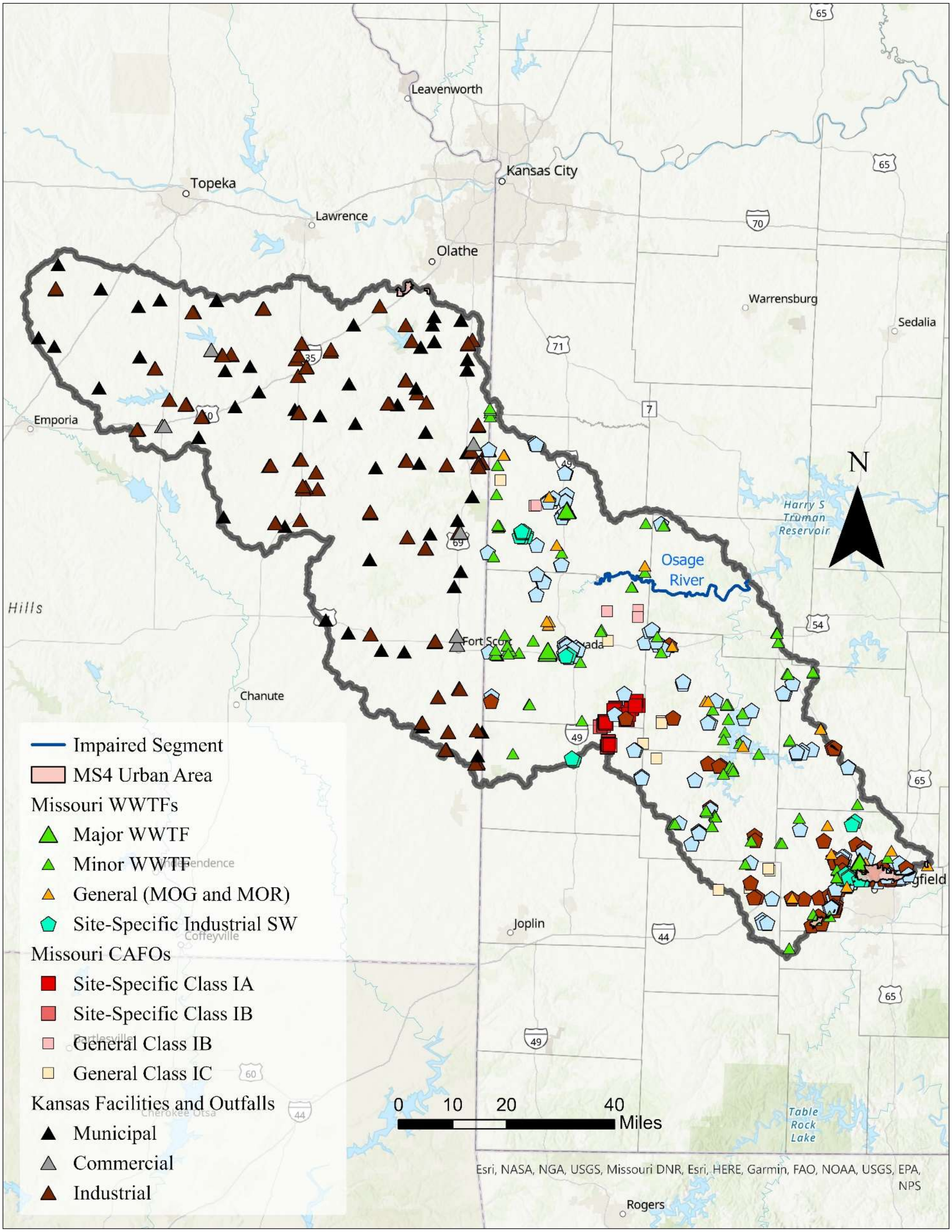

Figure 8. Permitted features and outfalls in the Osage River watershed

5.1.1 Domestic Wastewater Treatment Facilities

Domestic wastewater is primarily household waste, including graywater and sewage. Domestic wastewater treatment facilities include both publicly owned (municipal and sewer districts) and privately owned facilities. Untreated or inadequately treated domestic wastewater discharges can be significant sources of bacteria to receiving waters (USEPA 1986). For this reason, domestic wastewater treatment facilities are potential sources of *E. coli* loading to the Osage River. However, when operating as designed, facilities utilizing disinfection technologies discharge *E. coli* at very low concentrations and are not expected to cause or contribute to bacteria impairments through discharges of treated effluent. Facilities that use effluent for irrigation (land application) or otherwise do not directly discharge to streams during the recreational season are also not expected to cause or contribute to *E. coli* impairments when all permit conditions are met.

Table 6 lists the Missouri domestic wastewater dischargers in the Osage River watershed. A considerable number of the facilities found in the Osage River watershed are lagoon systems without disinfection, such as ultraviolet or chlorination treatment. 10 CSR 20-7.015 requires recreational season *E. coli* limits for all domestic wastewater treatment facilities within two miles upstream of waters with whole body contact designated uses. Facilities without disinfection can be potential sources of *E. coli* loading if not operated in a manner to mitigate significant *E. coli* loading during the recreational season. Facilities with disinfection generally do not contribute significant *E. coli* loading under normal operating conditions. Efforts to reduce facility loading to meet newly established wasteload allocations and to comply with applicable recreational criteria may include, but are not limited to, installation of disinfection infrastructure, effluent land application or irrigation, pump and haul operations, and seasonal batch discharging. Some lagoon systems with design flows above zero do not discharge during dry conditions and are therefore less likely to cause or contribute to the existing impairment. All discharging facilities in Table 6 have operating permits containing final *E. coli* effluent limits and are expected to comply with such limits or be subject to department enforcement actions.

Table 6. Domestic wastewater treatment facilities in the Osage River watershed in Missouri[12]

Permit No.	Facility Name	Treatment Type	Design Flow (ft^3/s)	Disinfection	Expires[13] (Year/Mo/Day)
MO0037052	Camp Clark Training Site WWTF	Lagoon	0.15	None	2027-03-31
MO0045837	Liberal WWTF	Lagoon	0.15	None	2022-06-30
MO0050172	South Park Mobile Village WWTF	Lagoon	0.01	None	2021-09-30
MO0125091	Amsterdam WWTF	Lagoon	0.04	None	2022-12-31
MO0128767	Amoret WWTF	Lagoon	0.05	None	2022-12-31
MO0103748	Rockville Wastewater Treatment Plant (WWTP)	Lagoon	0.04	None	2028-12-31
MO0059382	USCOE Mutton Creek Marina WWTF	Lagoon	0.002	None	2023-09-30

[12] As of May 2024

[13] When a NPDES permit expires, the permittee remains bound by the conditions of that expired permit until either the permit is terminated or a new permit is issued.

Permit No.	Facility Name	Treatment Type	Design Flow (ft^3/s)	Disinfection	Expires[13] (Year/Mo/Day)
MO0060178	USCOE Mutton Creek PUA WWTF	Lagoon	0.01	None	2023-09-30
MO0030473	Lockwood WWTF	Lagoon	0.37	Chlorine	2023-12-31
MO0060101	USCOE Cedar Ridge WWTF	Lagoon	0.01	None	2024-03-31
MO0060089	USCOE Ruark Bluff NE PUA WWTF	Lagoon	0.002	None	2024-06-30
MO0112241	Maranatha Bible Camp WWTF	Lagoon	0.02	Chlorine	2024-03-31
MO0118982	Flemington WWTF	Lagoon	0.03	None	2024-06-30
MO0103756	Collins WWTF	Lagoon	0.05	None	2023-09-30
MO0112810	Calypso Cove RV Park WWTF	Lagoon	0.01	None	2024-03-31
MO0113514	Fair Play WWTF	Lagoon	0.13	None	2023-09-30
MO0055603	Greenfield Talburt WWTF	Lagoon	0.18	None	2023-12-31
MO0134139	ADM Deerfield	Lagoon	0.05	Bromine/Chlorine	2028-09-30
MO0025739	Humansville WWTF	Lagoon	0.25	None	2024-06-30
MO0040177	Sheldon WWTF	Lagoon	0.11	None	2028-03-31
MO0103942	Walker WWTF	Lagoon	0.06	None	2027-10-31
MO0023655	Drexel North WWTF	Lagoon	0.08	None	2028-03-31
MO0120472	Bronaugh WWTF	Lagoon	0.04	None	2026-09-30
MO0021105	Appleton City WWTF	Lagoon	1.21	None	2027-06-30
MO0096229	Butler WWTP	Mechanical Plant	2.32	UV disinfection	2015-02-10
MO0114715	Hume WWTF	Mechanical Plant	0.03	None	2028-09-30
MO0040002	El Dorado Springs WWTP	Mechanical Plant	1.47	UV disinfection	2021-12-31
MO0089109	Nevada WWTP	Mechanical Plant	3.09	UV disinfection	2016-05-12
MO0092517	Rich Hill WWTF	Mechanical Plant	0.45	None	2028-09-30
MO0107174	Walnut Grove WWTP	Mechanical Plant	0.12	UV disinfection	2022-10-31
MO0093220	American Resort Subdivision WWTP	Mechanical Plant	0.01	Chlorine	2023-07-31
MO0042480	Billings WWTP	Mechanical Plant	0.19	Chlorine	2023-09-30
MO0030287	USACE Orleans Trail Park WWTF	Mechanical Plant	0.01	UV disinfection	2023-12-31
MO0055280	Stockton WWTP	Mechanical Plant	0.62	UV disinfection	2024-03-31

Permit No.	Facility Name	Treatment Type	Design Flow (ft^3/s)	Disinfection	Expires[13] (Year/Mo/Day)
MO0023205	Ash Grove WWTP	Mechanical Plant	0.52	UV disinfection	2023-12-31
MO0052281	Willows Utility Company WWTP	Mechanical Plant	0.15	Chlorine	2026-06-30
MO0103039	Springfield NW WWTP	Mechanical Plant	10.52	UV disinfection	2025-07-31
MO0022098	Republic WWTP	Mechanical Plant	4.95	UV disinfection	2024-03-31
MO0135933	MoDNR Stockton State Park WWTF	No Discharge	No discharge	UV disinfection	2023-09-30
MO0107808	Hudson R-9 School District WWTP	Sand/Rock Filter	0.004	None	2028-02-29
MO0127680	Agape Boarding School WWTP	Sand/Rock Filter	0.05	UV disinfection	2023-09-30
MO0119628	Pleasant View Estates HOA WWTF	Sand/Rock Filter	0.01	Chlorine	2023-09-30
MO0098191	Pilot Travel Center #385 WWTP	Sand/Rock Filter	0.02	Chlorine	2023-09-30
MO0123277	Good Samaritan Boys Ranch WWTF	Sand/Rock Filter	0.02	UV disinfection	2023-12-31
MO0118320	Everton WWTF	Sand/Rock Filter	0.07	UV disinfection	2023-12-31
MO0124311	Pleasant View School WWTP	Sand/Rock Filter	0.01	Chlorine	2023-09-30
MO0129747	South Greenfield WWTP	Sand/Rock Filter	0.10	UV disinfection	2024-06-30
MO0117455	Willard Central Elementary WWTP	Sand/Rock Filter	0.01	Chlorine	2024-06-30
MO0083241	Northeast Vernon County R-1 School WWTF	Sand/Rock Filter	0.005	None	2027-11-30
MOG823014	Sac Osage Electric Cooperative	Lagoon	No discharge	None	2027-08-24
MOG823046	Lake Meadows Mobile Home Park	Lagoon	No discharge	None	2027-08-24
MOG823054	Hoods Service Center Inc.	Lagoon	No discharge	None	2027-08-24

Potential bacteria loading from domestic wastewater treatment facilities may also occur from sanitary sewer overflows. Sanitary sewer systems convey residential wastewater, and in some cases commercial and industrial wastewater, to the domestic wastewater treatment facility (WWTF). Sanitary sewer systems can handle limited amounts of inflow from stormwater and infiltration from groundwater but are typically not designed to collect large amounts of runoff from precipitation events. Overflows from sanitary sewer systems may result in elevated bacteria counts in nearby surface waters (USEPA 1996). Sanitary sewer overflows (SSO) can be caused by high volume

precipitation events and can also occur during dry weather due to blockages, line breaks, sewer defects, power failures, and vandalism. Sanitary sewer overflows can occur at any point in the collection system but are typically evident by overflowing manholes and backups into private residences. Such overflows may discharge directly to nearby waterways or may be restricted to terrestrial locations. These discharges are not authorized by the federal Clean Water Act or the Missouri Clean Water Law.

Sanitary sewer overflows are generally expected to be rare and temporary in nature. Missouri State Operating permits and 40 CFR Part 122.41(e) require permittees to properly operate and maintain their facility's collection systems. This is implemented through a special permit condition or schedule of compliance. Approximately 706 SSO events have been reported in the Osage River watershed since 2014. Municipalities with significant SSO reporting include Billings WWTP (MO0042480), Republic WWTP (MO0042480), and Appleton City WWTP (MO0021105) each reporting more than one hundred events since 2014. While these events can be potential sources of *E. coli*, not all events reach surface waters or are significant in discharge volume. Insufficient data are available to determine the significance of *E. coli* contributions from SSO events.

5.1.2 Industrial and Commercial Facilities

Industrial and commercial facilities, shown in Table 7, discharge process wastewater used or generated during mining, manufacturing, or food processing activities, and may also include landfills. Mining and manufacturing facilities are not expected to cause or contribute to bacteria impairments. Food processing wastewater may contain bacteria. There are six facilities that hold general permits for small meat processors. Rich Hill Meat Processing is permitted under the subdivisions for a non-discharging earthen basin, land application of meat processing wastewater, animal holding area stormwater, and animal transfer stormwater. Cedar County Meat Market LLC and Missouri Beef Plant LLC are permitted under the subdivisions for non-discharging earthen basins and land application of meat processing wastewater. Cedar Creek Farms is permitted under the subdivisions for subsurface dispersal of meat processing wastewater, animal holding area stormwater, and non-discharging compost of meat processing material. Daniel Beachy and Bear Creek Meats LLC are permitted under the subdivision for land application of meat processing wastewater. Since these facilities are not permitted under subdivision A, which allows direct discharge of meat processing wastewater, they are not authorized to discharge to surface waters. If a facility meets all requirements of the relevant subdivision in the master general permit for small meat processors, it should not be a significant contributor of *E. coli* to the Osage River watershed.

There are two facilities, JW Willoughby Septic Tank Cleaning LLC, and Carl Winder, which hold general permits for land application of domestic waste. There are three facilities, American Beef Company LLC, Troyers Custom Meats, and McCord Backhoe and Trucking LLC, which hold general permits for land application of food processing wastewater. One facility holds a general permit for land application of animal compost wastewater. These facilities are not authorized to discharge to surface waters. If a facility meets all land application permit requirements, it should not be a significant contributor of *E. coli* to the Osage River watershed.

There are also three site-specific permitted industrial or commercial facilities in the Osage River watershed. ADM Deerfield (MO0134139) discharges stormwater and industrial process wastewater to a tributary of Green Branch (WBID 5054) and has domestic wastewater removed by a contract hauler. Hammons Products Company (MO0137669) operates a storage basin and wastewater irrigation system for industrial process water and conveys domestic wastewater to a separate

facility. The Walnut Creek Mine (MO0139912) discharges alkaline mine drainage wastewater and stormwater to a tributary of Walnut Creek (WBID 5052). These facilities do not discharge wastewater from processes that actively generate *E. coli* and are not expected to be a significant contributor of *E. coli* loading to the Osage River. In addition to these site-specific permits, there are several general permits for stormwater discharges from industrial and commercial facilities. Those other general permits are discussed in Section 5.1.5.

Table 7. Industrial and Commercial Facilities in the Osage River watershed in Missouri[14]

Permit No.	Facility Name	Permit Type	Expires (Year/Month/Day)
MOG140008	Travel Centers of the Ozarks Inc.	Oil and Water Separators	2024-06-30
MOG140086	Truckmovers - Springfield MO		2024-06-30
MOG220032 (Subdivisions B, D, F, G)	Rich Hill Meat Processing	Small Meat Processors	2027-06-30
MOG220044 (Subdivisions B, D)	Cedar County Meat Market LLC		2027-06-30
MOG220055 (Subdivisions B, D)	Missouri Beef Plant LLC		2027-06-30
MOG220100 (Subdivisions C, F, H)	Cedar Creek Farms –		2027-06-30
MOG220104 (Subdivision D)	Daniel Beachy		2027-06-30
MOG220035 (Subdivision D)	Bear Creek Meats LLC		2027-06-30
MOG640083	Fulbright Water Treatment Plant	Water Treatment Plant Settling Basins	2029-02-24
MOG640125	RICH HILL WTP		2029-02-24
MOG640151	Butler Water Treatment Plant		2029-02-24
MOG640239	Bates County PWSD No. 2	Water Treatment Plant Settling Basins	2029-02-24
MOG690016	Nuccitelli Pipeline Alternate Discharge	Dredging	2024-07-31
MOG760035	Mount Carmel Inn Swimming Pool	Swimming Pool Discharges	2024-07-31
MOG760219	Willard Aquatic Center		2024-07-31

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Permit No.	Facility Name	Permit Type	Expires (Year/Month/Day)
MOG821049	JW Willoughby Septic Tank Cleaning LLC	Land Application of Domestic Waste	2027-11-30
MOG821186	Carl Winder		2027-11-30
MOG822008	American Beef Company, LLC	Land Application Food Processing Wastewater	2027-05-31
MOG822229	Troyers Custom Meats		2027-05-31
MOG822247	McCord Backhoe and Trucking LLC		2027-05-31
MOG920007	Rockin' D Compost	Feedstock Compost sites	2028-01-24

5.1.3 Concentrated Animal Feeding Operations

Animal waste generated from CAFOs can be a source of bacteria to water bodies (Rogers and Haines 2005). Pursuant to 10 CSR 20-6.300, permits are required for CAFOs that confine and feed or maintain more than 1,000 animal units for 45 days or more during any 12-month period.[15] Permits may be required for facilities with fewer animal units if pollutants are discharged directly into waters of the state or other water quality issues are discovered. In Missouri, CAFOs operate under site-specific permits or one of two general permits (MO-G01 or MO-GS1). All CAFO facilities are permitted as no-discharge facilities. The MOGS1 permit does not authorize discharges for any reason. The MOG01 permit allows discharge only in the event of weather that exceeds the criteria of a catastrophic storm, and only authorizes discharge of the portion of the stormwater flow that exceeds the design storm event, which includes the direct precipitation and runoff from the 25-year, 24-hour storm event. These discharges are not expected to be significant contributors of *E. coli* to surface waters because they are rare and temporary in nature, and may only occur during the defined catastrophic storm events that generally result in high flows that are infrequently met or exceeded.

There are fifteen CAFOs present on the Missouri side of the Osage River watershed, two Class IA facilities, five Class IB facilities, and eight Class IC facilities (shown in Table 8).[16] Animal waste applied on areas under the control of a CAFO are subject to conditions found in the permit, which include a requirement for the CAFO to develop a nutrient management plan. Section 640.760 Revised Statutes of Missouri (RSMo) establishes setback distances for surface application of liquefied manure from a CAFO by a third party.[17] CAFOs violating their permit conditions as they relate to discharge or land application are potential sources of *E. coli* and may be subject to department enforcement action. When all permit requirements are met, CAFOs are not expected to

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[15] As defined by 10 CSR 20-6.300(1)(B)2, an animal unit is a unit of measurement to compare various animal types at an animal feeding operation. One (1) animal unit equals the following: 1.0 beef cow or feeder, cow/calf pair, veal calf, or dairy heifer; 0.5 horse; 0.7 mature dairy cow; 2.5 swine weighing over 55 pounds; 10 swine weighing less than 55 pounds; 10 sheep, lamb, or meat and dairy goats; 30 chicken laying hens or broilers with a wet handling system; 82 chicken laying hens without a wet handling system; 55 turkeys in grow-out phase; 125 chicken broilers, chicken pullets, or turkey poults in brood phase without a wet handling system.

[16] An operation's "class size" is a category that is based upon the total number of animal units confined at an operation. The Class IC, IB, and IA are categories that start at 1,000, 3,000, and 7,000 animal units respectively, all of which are required by state regulation to obtain a permit. (1,000 animal units is equal to 2,500 swine; 100,000 broilers; 700 dairy cows; or 1,000 beef steers).

[17] Section 640.760 RSMo requires all third party applicators of liquefied manure from CAFOs to maintain the following minimum setback distances: 50 feet from a property boundary, 300 feet from any public drinking water lakes, 300 feet from any public drinking water well or intake structure, 100 feet from any perennial and intermittent streams without vegetation abutting such streams, and 35 feet from any perennial and intermittent streams with vegetation abutting such streams.

be contributors of bacteria loading through direct discharge. Per Missouri Clean Water Law at 644.059 and 644.016(16) RSMo, and Missouri permit regulations at 10 CSR 20-6.300(1)(B)10, discharges of agricultural stormwater are separate from CAFO discharges and are considered nonpoint sources. Agricultural stormwater discharges are discussed in Section 5.2.

Table 8. Concentrated Animal Feeding Operations in the Osage River watershed in Missouri[18]

Permit No.	Facility Name	Permit Type	Expires (Year/Month/Day)
MO0131032	Murphy Family Ventures, Ozark-Osage Pyramid	Site-Specific CAFO (IA)	2023-09-30
MO0131041	Murphy Family Ventures, Doylesport Pyramid	Site-Specific CAFO (IB)	2024-06-30
MO0131059	Murphy Family Ventures, Dover Pyramid	Site-Specific CAFO (IB)	2027-03-31
MO0131067	Murphy Family Ventures, Bellamy Pyramid	Site-Specific CAFO (IA)	2026-09-30
MOG010565	Turkey Run	General CAFO IC	2028-02-29
MOG010574	Clayton Arnold	General CAFO IC	2028-02-29
MOGS10090	Pork Plus LLC	General CAFO IB	2028-02-13
MOGS10093	Kitten Creek North and South	General CAFO IB	2028-02-13
MOGS10104	Horizon Pork	General CAFO IC	2028-02-13
MOGS10239	NK Farm	General CAFO IC	2028-02-13
MOGS10249	Double L Poultry	General CAFO IC	2028-02-13
MOGS10397	WE Enterprises, LLC	General CAFO IC	2028-02-13
MOGS10420	Heiman Agri Services, Inc.	General CAFO IB	2028-02-13
MOGS10514	Thawng Tha Lian	General CAFO IC	2028-02-13
MOGS10567	Mulberry Creek Farms, LLC	General CAFO IC	2028-02-13

5.1.4 Municipal Separate Storm Sewer Systems

Municipal separate storm sewer systems (MS4s) are stormwater conveyance systems owned by a public entity that are not part of a sanitary sewer system, a combined sewer system, or part of a domestic wastewater treatment facility. Federal regulations issued in 1990 require that discharges from MS4s be regulated by permits if the population of a municipality, or in some cases a county, is 100,000 or more (Phase I). As of 1999, federal regulations require permits for discharges from small MS4s that are located within a U.S. Census Bureau defined urban area or are required to hold a MS4 permit based on other criteria by the permitting authority (Phase II). MS4 permits authorize the discharge of urban stormwater runoff. In general, urban runoff contains high levels of bacteria and may contribute to exceedances of *E. coli* criteria during and immediately after storm events in most streams throughout the county (EPA 1983). Runoff contaminated with *E. coli* flows from open areas where soil erosion is common and from heavily paved areas (EPA and Pitt 2002). Common sources of *E. coli* contamination in urban stormwater have been documented as originating from birds, dogs, cats, and rodents (Burton and Pitt 2002). Irrigation runoff from residential lawns where

[18] As of May 2024

pet wastes are present may also contribute *E. coli* loads to surface waters, as well as sanitary sewer overflows as discussed in Section 5.1.1. Regulated MS4s in the Osage River watershed are those maintained by the municipalities of Republic, Springfield, Strafford, and Bolivar; as well as Christian County and Green County (Figure 8 and Table 9). Additionally, the Missouri Department of Transportation (MoDOT) holds a statewide site-specific transportation separate storm sewer system (TS4) permit (MO0137910) that applies to stormwater discharges from MoDOT right-of-ways within the previously mentioned urban areas.

Table 9. Municipal Separate Storm Sewer Systems in the Osage River watershed in Missouri[19]

Permit No.	Facility Name	Permit Type	Expires (Year/Month/Day)
MOR040014	Greene County Phase II MS4	Storm Water Small MS4	2026-09-30
MOR04C021	Republic Phase II MS4	Storm Water Small MS4	2026-09-30
MOR04C054	Bolivar Phase II MS4	Storm Water Small MS4	2026-09-30
MOR04C078	Christian County Phase II MS4	Storm Water Small MS4	2026-09-30
MO0126322	Springfield Phase I MS4	Storm Water MS4	2027-04-30
MOR04C022	Strafford Phase II MS4	Storm Water Small MS4	2026-09-30

Although stormwater discharges are often untreated, MS4 and TS4 permit holders must develop, implement, and enforce stormwater management plans to reduce the contamination of stormwater runoff and prohibit illicit discharges. Stormwater management plans must include measurable goals, annual reports, and six minimum control measures. These control measures include public education and outreach, public participation and involvement, illicit discharge detection and elimination, construction site runoff control, post-construction runoff control, and pollution prevention. MS4 and TS4 permits may also require the development of supplemental TMDL Assumptions and Requirement Attainment Plans (ARAPs) where applicable. Missouri's list of regulated MS4s and associated stormwater management plans can be accessed at: https://dnr.mo.gov/water/business-industry-other-entities/permits-certification-engineering-fees/stormwater/municipal-separate-storm-sewer-systems-ms4.

Approximately 24.3 square miles (0.3 percent) of the Osage River watershed are contained within areas that may contribute stormwater runoff to regulated MS4s. Due to the small proportion of area potentially contributing stormwater to these systems in the Osage River watershed, especially in comparison to other potential sources described in this TMDL, small MS4s are not expected to be a significant contributor to the *E. coli* impairment of the Osage River. Unregulated urban runoff from other developed areas in the Osage River watershed is considered a nonpoint source and is discussed in Section 5.2.2.

5.1.5 Other General Permitted Wastewater and Stormwater Discharges

General permits are issued for certain wastewater (MOG) and stormwater (MOR) discharges based on the type of activity and are intended to be flexible enough to allow for ease and speed of issuance, but must also protect water quality. General wastewater and stormwater permits are issued for activities similar enough to be covered by a single set of requirements. Table 10 lists other general and stormwater discharge permits in the Osage River watershed that have not already been discussed in this TMDL. Permits associated with construction or land disturbance activities

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(MORA) are temporary. The number of permits of this type may vary in any given year. Despite this variation, activities associated with general construction or land disturbance permits are not expected to cause or contribute to *E. coli* impairments when all permit conditions are met.

Existing and future activities for which general wastewater or stormwater permits are issued are expected to be conducted in compliance with all permit conditions including monitoring requirements and discharge limitations. Permit conditions are intended to protect the designated uses of all water bodies within the watershed. For the facilities identified in Table 10, activities conducted in accordance with these general wastewater and stormwater permit requirements are not expected to contribute *E. coli* loads in amounts substantial enough to cause or contribute to surface water impairments. Per 10 CSR 20-6.010(13)(C), if at any time the department determines that a general permit is not providing adequate water quality protection, the department may require the owner or operator of a permitted site or activity to obtain a site-specific operating permit.

Table 10. Other General (MOG) and stormwater (MOR) permitted facilities in the Osage River watershed in Missouri[20]

Permit No.	Facility Name	Permit Type	Expires Year/Month/Day
MOG050087	Franklin Reclamation Project	Abandoned Mine Land	2026-10-31
MOG350159	MFA Oil Petro Card Nevada	Petroleum Storage	2027-09-17
MOG350276	MFA Oil Bulk Plant - Butler Bulk Plant		2027-09-17
MOG350284	MFA Oil Bulk Plant Nevada		2027-09-17
MOG350310	MFA Oil Bulk Plant Appleton City		2027-09-17
MOG350325	Crossroads Eagle Stop		2027-09-17
MOG350348	Fuel Marketing Corp Springfield Facility		2027-09-17
MOG350354	Nevada Municipal Airport		2027-09-17
MOG350355	Mid-West Fertilizer LLC		2027-09-17
MOG490006	Bailey Quarries Chesapeake Quarry	Limestone Quarries	2027-04-30
MOG490012	Bailey Quarries Stockton Quarry		2027-04-30
MOG490062	Golden City Quarry		2027-04-30
MOG490084	Bailey Quarries Inc. Fall Valley		2027-04-30
MOG490105	HSG 474 Rich Hill Quarry		2027-04-30
MOG490107	HSG 471 Butler Quarry		2027-04-30
MOG490112	Conco Co Montevallo Quarry		2027-04-30

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Permit No.	Facility Name	Permit Type	Expires Year/Month/Day
MOG490215	Phenix Quarry LLC		2027-04-30
MOG490229	Conco Co Fair Play Quarry		2027-04-30
MOG490264	Conco Co Willard Quarry		2027-04-30
MOG490479	Conco Co Stockton Quarry		2027-04-30
MOG490493	Ewing Concrete		2027-04-30
MOG490543	Willard Asphalt Plant		2027-04-30
MOG490556	Rite Way Concrete Products Co		2027-04-30
MOG490748	Allen Quarries Inc.		2022-04-30
MOG490781	AGA 487 Lackey Quarry		2022-04-30
MOG490820	Adrian Quarry		2027-04-30
MOG490913	HSG 486 Dever Quarry		2027-04-30
MOG490973	Kifer Quarry		2027-04-30
MOG490978	Allen Quarries Inc. 2		2022-04-30
MOG490983	HSG 473 Seagraves Quarry		2027-04-30
MOG491056	HSG 470 Butler Quarry		2027-04-30
MOG491113	HSG 476 La Cygne Quarry		2027-04-30
MOG491219	Nevada Concrete Inc.		2027-04-30
MOG491271	Westside Stone LLC		2027-04-30
MOG491286	Deerfield Quarry		2027-04-30
MOG491306	Fair play Quarry		2027-04-30
MOG491319	Ozark Wilbert Vault Republic		2027-04-30
MOG491371	Lone Oak Quarry		2027-04-30
MOG491450	Ready Concrete Services		2027-04-30
MOG491467	Vernon County Ready Mix		2027-04-30
MOG491483	Springfield Airport		2027-04-30
MOG491507	Emery Sapp and Sons Springfield Asphalt		2027-04-30
MOG491512	Magruder Paving LLC Butler CRD 2501		2027-04-30
MOG491513	Magruder Paving LLC Butler I-49 and 52		2027-04-30
MOG491538	Woodcrest No 1		2027-04-30
MOG491543	Greenfield Ready Mix and Materials Inc.		2027-04-30
MOG491555	Rost Ready Mix		2027-04-30
MOG870004	McDaniel Lake	Pesticide Application	2026-12-31

Permit No.	Facility Name	Permit Type	Expires Year/Month/Day
MOR130116	Murphy Brown LLC Feed Mill	Textile and Apparel/ Printing and Publishing	2028-10-22
MOR130123	DairiConcepts, LP		2028-10-22
MOR130143	French's Food Co		2028-10-22
MOR130146	J and A Recycling		2028-10-22
MOR130156	Hiland Dairy Foods LLC		2028-10-22
MOR130177	NF Protein Nevada Plant		2028-10-22
MOR203126	Ridewell Corporation	Fabricating Metal/Light Industrial	2024-08-31
MOR203169	Gardner Denver Inc.		2024-08-31
MOR203291	John Deere Reman - Springfield		2024-08-31
MOR203303	Loren Cook Company - Barnes Plant		2024-08-31
MOR203358	Executive Coach Builders, Inc.		2024-08-31
MOR203365	Falcon Steel Inc.		2024-08-31
MOR203380	Abec Inc.		2024-08-31
MOR203385	Central States Industrial		2024-08-31
MOR203479	Multi-Craft Contractors Inc.		2024-08-31
MOR203507	Diesel Exchange Inc.		2024-08-31
MOR203529	Jenfab Cleaning Solutions		2024-08-31
MOR203536	Stainless Fabrication, Inc.		2024-08-31
MOR203540	Peerless Products ISG		2024-08-31
MOR22A022	South Side Lumber Company	Lumber and Wood Primary	2024-09-16
MOR22A325	BSB Tie Company, Inc.		2024-09-16
MOR22A367	Springfield Pallet Co Inc.		2024-09-16
MOR23D110	Buckhorn Inc.	Plastics and Rubber Manufacturing	2027-05-09
MOR23D115	Alltrista Plastics LLC		2027-05-09
MOR23D146	Foam Fabricators, Inc.		2027-05-09
MOR23D161	United Poly Systems		2027-05-09
MOR23D176	Barnett Salvage Inc.		2027-05-09
MOR240204	Ag Service of Lockwood Inc.	Agrichemical Facilities	2024-04-30
MOR60A177	All Parts Auto and Truck Salvage	Motor Vehicle Salvage	2028-12-11
MOR60A212	Scott Salvage Yard LLC		2028-12-11
MOR60A333	Browns Iron and Metal		2028-12-11
MOR60A420	McInroy Construction Inc.		2028-12-11
MOR60A421	Eldo Metal Recycling		2028-12-11
MOR60A431	Meadows Auto Inc.		2028-12-11
MOR60A433	All States Ag Parts LLC		2028-12-11

Permit No.	Facility Name	Permit Type	Expires Year/Month/Day
MOR60A456	King Krusher		2028-12-11
MOR60A461	Highland Auto Parts		2028-12-11
MOR80C009	Reaves Delivery Services	Motor Freight Transportation	2027-11-30
MOR80C040	Prime Inc. Headquarters		2027-11-30
MOR80C270	Indiana Western Express Inc.		2027-11-30
MOR80C403	XPO Logistics Freight Inc. XFR		2027-11-30
MOR80C494	FedEx Freight Inc. SGF		2027-11-30
MOR80C530	MoDNR Stockton State Park Marina		2027-11-30
MOR80C568	McLane Ozark		2027-11-30
MOR80C570	R and L Carriers		2027-11-30
MOR80C606	Prime Inc. Service Center East		2027-11-30
MOR80C638	YRC Freight 547		2027-11-30
MOR80C663	Amazon.com Services LLC - STL3		2027-11-30
MORA19724	Hood's Service Center, Inc.	Land Disturbance	2027-02-07
MORA19804	Drury Lane Extension/Hankins Farm		2027-02-07
MORA19809	Stone Creek Falls		2027-02-07
MORA19840	Convoy of Hope New World Headquarters		2027-02-07
MORA19942	El Dorado Manufacturing Facility		2027-02-07
MORA20058	Sub 498 - Greenfield		2027-02-07
MORA20069	F5 Poultry		2027-02-07
MORA20107	W Farm Road 140		2027-02-07
MORA20213	Samuel Kropf Chicken Farm		2027-02-07
MORA20237	Flint Hill Branch Stabilization		2027-02-07
MORA20300	Duvall Real Estate, LLC		2027-02-07
MORA20328	KCS Bridge K-107.6		2027-02-07
MORA20386	Republic Early Childhood		2027-02-07
MORA20424	DOLING LANDING LP		2027-02-07
MORA20506	Springfield Inn Demo and Grading		2027-02-07
MORA20522	Emerald Valley		2027-02-07
MORA20560	Springfield Sports Complex		2027-02-07
MORA20584	Birch Pointe Subdivision		2027-02-07

Permit No.	Facility Name	Permit Type	Expires Year/Month/Day
MORA20606	Take 5 Car Wash and Oil Change	Land Disturbance	2027-02-07
MORA20617	ESS - Springfield Asphalt Plant		2027-02-07
MORA20643	Reeds Plumbing		2027-02-07
MORA20683	Iron Grain		2027-02-07
MORA20754	ATM		2027-02-07
MORA20829	Hoffman Hills Subdivision		2027-02-07
MORA20897	Jared Warehouse		2027-02-07
MORA20946	Eagle Stop - Brookline		2027-02-07
MORA20966	Jordan Valley Community Health Center		2027-02-07
MORA21106	G and E Self Storage		2027-02-07
MORA21185	Go Car Wash		2027-02-07
MORA21238	Stone Creek planned development		2027-02-07
MORA21241	Kuat Innovations		2027-02-07
MORA21263	Kearney St. Fill Area		2027-02-07
MORA21356	Arcola RV		2027-02-07
MORA21531	Mister Car Wash MO 1752		2027-02-07
MORA21719	Buc-ee's		2027-02-07
MORA21723	West Farm Road 104		2027-02-07
MORA21724	Dollar General #24537 Willard		2027-02-07
MORA21738	Orchard Park Apartments		2027-02-07
MORA21829	Industrial Services Company		2027-02-07
MORA21999	Ten Mile Sow Farm		2027-02-07
MORA22053	Kacie Burks		2027-02-07
MORA22109	I 44 Development		2027-02-07
MORA22166	j.hexcavating		2027-02-07
MORA22213	F and H Food Equipment Co.		2027-02-07
MORA22243	WALNUT RIDGE RV ESTATES INC.		2027-02-07
MORA22308	Praise Assembly		2027-02-07
MORA22325	Dollar General		2027-02-07
MORA22393	Garton 4		2027-02-07
MORA22650	Pond Expansion		2027-02-07
MORA22668	SPRINGFIELD-BRANSON NATIO		2027-02-07

Permit No.	Facility Name	Permit Type	Expires Year/Month/Day
MORA22713	Crown Meadows Phase Six		2027-02-07
MORA22737	Cabinet Concepts		2027-02-07
MORA22885	New Arena Building		2027-02-07
MORA23154	The Gathering Tree Inc.		2027-02-07

5.1.6 Illicit Straight Pipe Discharges
Illicit straight pipe discharges of domestic wastewater are also potential sources of bacteria. These types of sewage discharges bypass treatment systems, such as septic tanks or sanitary sewers, and discharge directly to a stream or an adjacent land area (Brown and Pitt 2004). Illicit straight pipe discharges are illegal and are not authorized by the federal Clean Water Act or the Missouri Clean Water Law. At present, there are no data about the presence or number of illicit straight pipe discharges in the Osage River watershed. For this reason, it is unknown to what significance straight pipe discharges contribute bacteria loads to surface waters in the watershed. Due to the illegal nature of these discharges, any identified illicit straight pipe discharges must be eliminated. In areas with a regulated MS4, illicit discharge detection and elimination is a required permit condition.

5.2 Nonpoint Sources
Nonpoint sources are diffuse sources with no discernible, confined, or discrete conveyance, and include all categories of discharge that do not meet the definition of a point source. Nonpoint sources are not regulated by the federal Clean Water Act and are exempt from department permit requirements by state regulation 10 CSR 20-6.010(1)(B)1. Nonpoint source pollutants are typically transported by stormwater runoff, which is minor or negligible during dry weather conditions. Although there are no available *E. Coli* data to indicate contributions from specific nonpoint sources, common nonpoint sources that have the potential to contribute bacteria loading to surface waters include runoff from agricultural lands, onsite wastewater treatment (septic) systems, and runoff from developed areas that do not have regulated storm sewer systems. Runoff from agricultural lands used for land application of wastewater or sludge from permitted facilities, including CAFOs, is also considered a nonpoint source, so long as the activities meet agricultural practices and agronomic land application rates, without direct discharge from land application activities. Nonpoint source pollution can also result from natural background contributions, such as wildlife waste. Streams with little to no riparian buffer are most susceptible to nonpoint source pollution. The department provides guidance and examples of BMPs to help reduce pollutant loading from nonpoint sources in the supplemental Osage River Nonpoint Source Implementation Strategies document at: https://dnr.mo.gov/water/what-were-doing/water-planning/quality-standards-impaired-waters-total-maximum-daily-loads/tmdls. These actions are voluntary and not a requirement of this TMDL. However, efforts to reduce pollutant loading from any potential nonpoint source contributor in the watershed is encouraged and will aid in meeting the water quality goals of this TMDL.

5.2.1 Agricultural Lands
Runoff from croplands, pasturelands, and low-density animal feeding operations is a potential source of bacteria to surface waters. Bacteria are transported in runoff from areas fertilized with animal manure and where livestock are present. Runoff can result from precipitation or excessive irrigation. Areas where nutrient management plans guide manure application and where BMPs are

used to reduce soil erosion contribute less bacteria to surface waters than unmanaged areas. Soil and Water Conservation Districts provide funding and guidance for the development of nutrient management plans for unregulated private lands. Although grazing areas are typically well vegetated, livestock tend to congregate near feeding and watering areas, which can create barren areas that are susceptible to erosion (Sutton 1990). Additionally, livestock that are not excluded from streams will deposit manure and thus bacteria directly into the waterway.

As noted in Section 2.4 of this document, 16 percent of the watershed is cropland and 46 percent of the watershed is pastureland in Missouri. Aside from livestock present in permitted CAFOs, the exact type and number of livestock present in the Osage River watershed is unknown. The number of cattle in each watershed can be estimated from county cattle population numbers provided in the U.S. Department of Agriculture's 2017 Census of Agriculture. Using the total number of cattle in Barton, Bates, Cass, Cedar, Dade, Greene, Lawrence, Polk, St. Clair, Vernon counties, and the proportion of each county's pastureland area in the watershed to the total pastureland area in each county, it is estimated that there are 407,046 cattle on the Missouri side of the Osage River watershed (NASS 2017). The U.S. Department of Agriculture estimates that a 1,000-pound beef cow produces approximately 59.1 pounds (26.8 kilograms) of manure per day (USDA 1995). Another study found that one gram of fresh manure from a cow on pasture contains a population of approximately 758,577 *E. coli* (Weaver et al. 2005).

Other types of livestock such as horses, sheep, pigs, and poultry may also be contributing bacteria loads in the Osage River watershed. The number and distribution of other animals in the watershed cannot be estimated from available data.

5.2.2 Runoff from Developed Areas

Developed areas where stormwater discharges are not regulated through MS4 permits are nonpoint sources of *E.* coli loading. Sources of *E. coli* loading within such developed areas are similar to those previously described for in Section 5.1.4. As presented in Section 2.4, developed areas cover small portions of the total Osage River watershed. On the Missouri side of the watershed, low to high intensity development comprises approximately 0.15 percent and open space comprises approximately 0.14 percent. Degradation of water quality associated with imperviousness has been shown to first occur in a watershed at about 10 percent total imperviousness and to increase in severity as imperviousness increases (Arnold and Gibbons 1996; Schueler 1994). Due to the small amount of development in the watershed, runoff from developed areas is not expected to contribute substantial amounts of *E. coli* to the Osage River. If the developed areas are expanded in the future, BMPs and low impact development should be considered to mitigate pollutant loading from impervious surfaces.

5.2.3 Onsite Wastewater Treatment Systems

Onsite wastewater treatment systems treat and disperse domestic wastewater on the property where it is generated. When properly designed and maintained, these systems perform well and should not contribute substantial amounts of *E. coli* to surface waters. However, when these systems fail hydraulically (surface breakouts) or hydrogeologically (inadequate soil filtration), there can be adverse effects to surface water quality (Horsley and Witten 1996). Non-discharging systems of domestic wastewater having flows of 3,000 gallons per day or less may operate under a permit exemption as described in 10 CSR 20-6.010(1)(B)11 and 10 CSR 20-6.015(3)(B)6. These facilities should not discharge and are therefore not expected to contribute *E. coli* to surface waters. The Missouri Department of Health and Senior Services or local administrative authorities (commonly

the local health department) have jurisdiction over onsite wastewater treatment systems with a design or actual flow of 3,000 gallons per day or less. Municipalities or counties may impose more stringent or additional requirements for owners of onsite systems. The Missouri Department of Health and Senior Services estimates that approximately 25 percent of homes in Missouri use onsite wastewater treatment systems, particularly in rural areas where public sewer systems are not available (DHSS 2018). Failing onsite wastewater treatment systems can contribute *E. coli* to nearby streams under wet or dry weather conditions directly or through surface runoff and groundwater flows. Factors that may contribute to onsite wastewater treatment system failure include age, inadequate land area, poor soil for drainage, high water table, and inadequate maintenance. Proper maintenance of onsite wastewater treatment systems including septic tanks, associated drain fields, and household lagoons should minimize bacteria loading to surface waters.

The exact number of onsite wastewater treatment systems in the Osage watershed is unknown. EPA's online input data server for the Spreadsheet Tool for Estimating Pollutant Load (STEPL) provides estimates of septic system numbers by 12-digit HUC watershed based on 1992 and 1998 data from the National Environmental Service Center (USEPA 2014b).[21] These STEPL derived estimates of septic system numbers are provided in Table 11. Based on this information, there are approximately 32,470 septic systems in the entire watershed and 25,417 in the Missouri side of the watershed. Due to the increase in population since the 1990 census, actual septic system numbers may be greater.

Septic systems fail due to age and poor maintenance. A study by the Electric Power Research Institute suggests that in parts of Missouri, up to 50 percent of onsite wastewater treatment systems may be failing (EPRI 2000). Due to this high failure rate, onsite wastewater treatment systems are potential sources of bacteria loading to surface waters in Missouri. However, the significance of such contributions to the impairment of the Osage River is unknown. The greater the distance an onsite system is located from a surface water, the less likely it is to cause contamination (MU Extension 2023).

Table 11. STEPL derived estimates of septic system numbers

Watershed Name	HUC12	Septic Systems	Population per Septic System
Bull Creek-Hillsdale Lake	102901020101	277	2
Little Bull Creek-Hillsdale Lake	102901020102	419	3
Rock Creek-Hillsdale Lake	102901020103	306	3
Ten Mile Creek	102901020104	510	3
North Wea Creek	102901020105	361	3
South Wea Creek	102901020106	456	3
Miloa Lake-South Wea Creek	102901020107	290	3
Walnut Creek-Bull Creek	102901020108	731	3
Jordan Branch-Marais des Cygnes River	102901020201	154	3
Elm Branch-Marais des Cygnes River	102901020202	127	3
Mound Creek-Middle Creek	102901020203	69	2
Hushpuckney Creek-Middle Creek	102901020204	121	2
Elm Creek-Marais des Cygnes River	102901020205	140	2

[21] The National Environmental Services Center is located at West Virginia University and maintains a clearinghouse for information related to, among other things, onsite wastewater treatment systems. Available URL: www.nesc.wvu.edu/

Watershed Name	HUC12	Septic Systems	Population per Septic System
Upper Middle Creek	102901020206	192	3
Lower Middle Creek	102901020207	212	2
Upper North Sugar Creek	102901020208	397	2
Lower North Sugar Creek	102901020209	95	2
Town of La Cygne-Marais des Cygnes River	102901020210	189	2
South Fork Sugar Creek	102901020301	53	2
Sugar Creek	102901020302	37	2
Saline Creek	102901020303	37	2
North Sugar Creek	102901020304	93	2
Davis Creek-Big Sugar Creek	102901020305	98	2
Upper Little Sugar Creek	102901020306	68	2
Lower Little Sugar Creek	102901020307	191	2
Richland Creek-Big Sugar Creek	102901020308	112	2
Muddy Creek-Marais des Cygnes River	102901020401	266	2
Mine Creek	102901020402	227	2
Spy Mound-Marais des Cygnes River	102901020403	41	2
Knob Creek	102901020501	23	2
Headwaters Miami Creek	102901020502	123	2
Bones Branch-Miami Creek	102901020503	312	2
Mound Branch	102901020504	682	2
Ehart Branch-Miami Creek	102901020505	114	2
Possum Branch-Miami Creek	102901020506	113	2
Mulberry Creek-Marais Des Cygnes River	102901020601	234	2
Walnut Creek	102901020602	75	2
New Home Creek	102901020603	26	2
Parker Branch-Marais Des Cygnes River	102901020604	207	2
Double Branch	102901020701	13	2
Sycamore Branch-Marais des Cygnes River	102901020702	30	2
Middle Fork Little Osage River-Little Osage River	102901030101	144	2
South Fork Little Osage River-Little Osage River	102901030102	43	2
Limestone Creek	102901030103	33	2
Irish Creek-Little Osage River	102901030104	83	2
Lost Creek-Little Osage River	102901030105	69	2
Elk Creek-Little Osage River	102901030106	141	2
Indian Creek-Little Osage River	102901030107	213	2
Duncan Creek	102901030201	50	2
Pryor Creek	102901030202	11	2
Bitterroot Creek-Little Osage River	102901030203	63	2
Reed Creek-Little Osage River	102901030204	236	2
Hightower Creek-Little Osage River	102901030205	40	2
Little Osage River	102901030206	233	2
Sweet Branch-Marmaton River	102901040101	111	2
Tennyson Creek-Marmaton River	102901040102	35	2
Turkey Creek-Marmaton River	102901040103	80	2
Hinton Creek-Paint Creek	102901040104	33	2
Elm Creek-Pawnee Creek	102901040105	58	2
Bunion Creek-Paint Creek	102901040106	43	2

Watershed Name	HUC12	Septic Systems	Population per Septic System
Cedar Creek-Marmaton River	102901040107	97	2
Lake Fort Scott-Marmaton River	102901040108	306	2
East Fork Dry Wood Creek	102901040201	195	2
Headwaters Dry Wood Creek	102901040202	144	2
McKill Creek	102901040203	113	2
Richland Creek-West Fork Dry Wood Creek	102901040204	102	2
Cox Creek	102901040205	225	2
Walnut Creek-West Fork Dry Wood Creek	102901040206	65	2
Buck Run-West Fork Dry Wood Creek	102901040207	63	2
Blue Mound-Dry Wood Creek	102901040208	26	2
Moores Branch	102901040209	141	2
Martin Mound-Dry Wood Creek	102901040210	34	2
Dry Wood Creek	102901040211	100	2
Mill Creek	102901040301	166	2
Shiloh Creek	102901040302	26	2
Wolverine Creek-Marmaton River	102901040303	1045	2
Cottonwood Creek-Marmaton River	102901040304	107	2
Headwaters Little Drywood Creek	102901040401	92	2
Pleasant Run Creek	102901040402	209	2
Little Creek-Little Dry Wood Creek	102901040403	27	2
Moore Branch	102901040404	220	2
Prairie Flower Branch-Little Dry Wood Creek	102901040405	113	2
Little Dry Wood Creek	102901040406	803	2
Twomile Creek-Marmaton River	102901040501	75	2
Old Town Branch	102901040502	136	2
Marmaton River	102901040503	977	2
Headwaters Clear Creek	102901050101	92	2
McCarty Creek-Clear Creek	102901050102	48	2
Robinson Branch	102901050103	78	2
West Fork Clear Creek	102901050104	232	2
Mulberry Creek-Clear Creek	102901050105	13	2
Fly Creek-Clear Creek	102901050106	322	2
Kitten Creek-Clear Creek	102901050107	806	2
Clear Creek	102901050108	86	2
Ladies Branch	102901050201	14	2
Camp Branch	102901050202	11	2
Panther Creek	102901050203	154	2
Shaw Branch-Osage River	102901050204	56	2
Campbell Branch-Osage River	102901050205	128	2
Baker Branch-Osage River	102901050206	41	2
Upper Weaubleau Creek	102901050301	176	2
South Fork Weaubleau Creek	102901050302	302	1
Middle Weaubleau Creek	102901050303	329	1
Harry S Truman Reservoir-Lower Weaubleau Creek	102901050304	100	2
Salt Creek-Osage River	102901050405	23	2
Gallinipper Creek-Harry S Truman Reservoir-Osage River	102901050406	350	2
Goose Creek	102901060101	211	2

Watershed Name	HUC12	Septic Systems	Population per Septic System
Headwaters Turnback Creek	102901060102	244	2
Billie Creek-Turnback Creek	102901060103	293	2
Sinking Creek	102901060104	319	2
Sycamore Branch-Turnback Creek	102901060105	98	2
Limestone Creek	102901060106	152	2
Turnback Creek	102901060107	205	2
Pickerel Creek	102901060201	711	2
Headwaters Sac River	102901060202	389	2
Sycamore Creek-Sac River	102901060203	214	2
Headwaters Clear Creek	102901060204	944	2
Clear Creek	102901060205	209	2
Dry Branch-Sac River	102901060206	348	2
Cave Spring Branch-Sac River	102901060207	336	2
Headwaters Sons Creek	102901060301	290	2
Sons Creek	102901060302	62	2
South Dry Sac River	102901060401	1791	2
Headwaters Little Sac River	102901060402	287	2
North Dry Sac River	102901060403	287	2
Flint Hill Branch-Little Sac River	102901060404	757	2
Slagle Creek	102901060405	328	2
Asher Creek-Little Sac River	102901060406	292	2
Turkey Creek	102901060501	204	2
Walnut Creek-Little Sac River	102901060502	183	2
Little Sac River	102901060503	467	2
Upper Bear Creek	102901060601	469	2
Spring Creek	102901060602	218	2
Middle Bear Creek	102901060603	129	2
Lower Bear Creek	102901060604	225	2
Birch Branch-Sac River	102901060701	30	2
Googer Creek-Sac River	102901060702	127	2
Stockton Lake Dam-Sac River	102901060703	329	2
Headwaters Horse Creek	102901060801	268	2
Patton Branch-Horse Creek	102901060802	32	2
Bear Creek-Horse Creek	102901060803	76	2
Horse Creek	102901060804	58	2
Headwaters Cedar Creek	102901060901	34	2
Connor Branch-Cedar Creek	102901060902	24	2
Snag Branch-Cedar Creek	102901060903	109	2
Adler Creek	102901060904	179	2
Cedar Creek	102901060905	128	2
Stockton Branch-Sac River	102901061001	485	2
Turkey Creek	102901061002	48	2
Headwaters Brush Creek	102901061003	488	2
Brush Creek	102901061004	38	2
Haynie Branch-Sac River	102901061005	60	2
Coon Creek	102901061006	293	2
Sac River Outlet	102901061007	94	2

5.2.4 Natural Background Contributions

Wildlife such as deer, waterfowl, raccoons, rodents, and other animals contribute to the natural background concentrations of *E. coli* that may be found in a water body. Such contributions may be a component of runoff from agricultural areas, developed areas, forest lands, and other areas. While typical wildlife populations are not expected to cause or contribute to water body impairments, animals that congregate in large groups on or near water bodies may contribute significant bacteria to surface waters. For instance, Canada geese have been found to contribute significant bacteria loads in some waters (Ishii et al. 2007). There are no watershed-specific population data for Canada geese or other waterfowl, but the Missouri Department of Conservation conducts statewide surveys in fall and winter. In 2020, waterfowl counts ranged from approximately 59,000 in October to 760,000 in late November (MDC 2021). The exact number of deer in the watershed is also not known, but the Missouri Department of Conservation keeps harvest records by county for each hunting season. Harvest data provides a general idea of the amount of deer that may be present in an area. The yearly harvests for the 2022- 2023 season on the Missouri side of the Osage River watershed was approximately 402 in Barton county, 456 in Bates county, 591 in Cass county, 481 in Cedar county, 334 in Dade county, 762 in Greene county, 424 in Lawrence county, 574 in Polk county, 743 in S. Clair county, and 697 in Vernon county (MDC 2023). Background concentrations of bacteria may also be present in benthic sediments and, if disturbed, can be resuspended as bacteria lives longer in the sediment than in water (Davis and Barr 2006; Marino and Gannon 1991). Resuspension has been found to occur during sediment disturbance and activities such as dredging, boating in shallow area, and swimming. The significance of any resuspended bacteria to the impairment in the Osage River is unknown. Natural background contributions are included in the nonpoint source load allocation.

5.2.5 Riparian Corridor Conditions

Riparian corridor conditions have a strong influence on instream water quality. Wooded riparian buffers are a vital functional component of stream ecosystems and are instrumental in the attenuation of pollutants in runoff. Land cover within 100 feet of streams in the Osage River watershed are presented in Table 12. Agricultural areas constitute over 55 percent of the riparian corridors of streams on the Missouri side of the Osage River watershed. These areas may be more susceptible to *E. coli* loading. Thirty-three percent of the riparian corridors are forested. This indicates that some *E. coli* transported from adjacent lands into those areas may be intercepted before it enters the streams.

Table 12. Land cover in riparian corridors on the Missouri side of the Osage River watershed

Land Cover Type	Square Miles	Percent
Developed, High Intensity	0.45	0.21%
Developed, Medium Intensity	1.60	0.74%
Developed, Low Intensity	4.19	1.94%
Developed, Open Space	12.55	5.81%
Barren Land	0.00	0.00%
Cultivated Crops	0.11	0.05%
Grassland and Pasture	119.94	55.54%
Shrub and Herbaceous	1.36	0.63%

Forest	73.02	33.81%
Wetlands	0.24	0.11%
Open Water	2.48	1.15%
Total	215.94	100%

6. Calculating Loading Capacity

A TMDL is equal to the loading capacity of a water body for a specific pollutant, which is the maximum pollutant load that a water body can assimilate and still attain and maintain water quality standards. The loading capacity is derived from the numeric water quality criterion for each pollutant or an appropriate surrogate when no numeric criterion is applicable. Once the maximum allowable pollutant load is determined, a portion is assigned to point sources as a wasteload allocation and to nonpoint sources as a load allocation. The Clean Water Act at Section 303(d)(1)(C) and federal regulations at 40 CFR 130.7(c)(1) also require TMDLs to incorporate a margin of safety. The margin of safety accounts for uncertainties in scientific and technical understanding of water quality in natural systems and provides assurance that water quality standards will be achieved after all wasteload and load allocations are met. The loading capacity is equal to the sum of the wasteload allocation, load allocation, and the margin of safety as follows:

$$\text{TMDL} = \text{LC} = \sum\text{WLA} + \sum\text{LA} + \text{MOS}$$

where LC is the loading capacity, ∑WLA is the sum of the wasteload allocations, ∑LA is the sum of the load allocations, and MOS is the margin of safety.

7. Total Maximum Daily Loads

According to 40 CFR 130.2(i), TMDLs can be expressed in terms of mass per unit time, toxicity, or other appropriate measures. The TMDL for the Osage River is expressed as *E. coli* cfu per day using a load duration curve developed using the *E. coli* criterion concentration of 126 cfu/100 mL, all possible stream flows, and a unit conversion factor.[22] Establishing TMDLs using load duration curves is consistent with the Anacostia Ruling (*Friends of the Earth, Inc., et al v. EPA,* No 05-5010, April 25, 2006) and EPA guidance in response to that ruling (USEPA 2006; USEPA 2007a).

The selected TMDL target is protective of whole body and secondary contact recreational uses. The resulting load duration curve provides a visual representation of the pollutant loading capacity of the water body at all stream flows. The TMDL is applicable during the recreational season when the *E. coli* criterion applies. Using this approach, the available loading capacity of the stream varies with flow, but the pollutant concentration remains constant. Although TMDLs are expressed as daily mass loads, Missouri's *E. coli* criteria are expressed as geometric mean concentrations. Therefore, fluctuations in instantaneous concentrations are expected and individual bacteria measurements greater than the applicable criterion do not necessarily indicate a violation of water quality standards. Additional discussion about the methods used to develop the load duration curve for the Osage River is provided in Appendix B.

Observed data are plotted on the load duration curve graph to illustrate the frequency and magnitude of exceedance. Points above the curve exceed the loading capacity and points on or below the curve

[22] $\boldsymbol{Load}\left(\frac{\text{count}}{\text{time}}\right) = \boldsymbol{Concentration}\left(\frac{\text{count}}{\text{volume}}\right) * \boldsymbol{Flow}\left(\frac{\text{volume}}{\text{time}}\right) * \boldsymbol{conversion\ factor}\ (24{,}465{,}715)$

are in compliance with water quality standards. The load duration curve also helps to identify and differentiate between storm-driven loading and the presence of continuous loading. Storm-driven loading is expected under wet conditions when precipitation and runoff are high. Continuous loading is evident at low flows when point source discharges have greater influence on water quality. Load reductions needed to meet the *E. coli* criterion can be estimated using the geometric means of observed data within each flow percentile range and are provided in the supplemental Implementation Strategies document located at: https://dnr.mo.gov/water/what-were-doing/water-planning/quality-standards-impaired-waters-total-maximum-daily-loads/tmdls.

The *E. coli* load duration curve for the Osage River is displayed in Figure 9. The y-axis quantifies the *E. coli* mass load in cfu per day at the flow conditions (percentage of time a particular flow is equaled or exceeded) on the x-axis. Lower flows are equaled or exceeded more frequently than higher flows (i.e., greater than 90 percent of the time). The flow ranges presented are consistent with EPA guidance for using load duration curves to develop TMDLs (USEPA 2007b).

The TMDL for the Osage River and associated allocations at selected percentile flow exceedances are displayed in Tables 13 and 14. Due to the extremely large numbers associated with bacteria loads, *E. coli* values are presented using scientific notation. Specific allocations for individual sources are discussed in Sections 8 and 9.

Table 13. *E. coli* TMDL and allocations for the Osage River at selected flows

Percent of time flow is equaled or exceeded	Flow ft^3/s	LC (cfu/day)	Facilities WLA (cfu/day)	MS4 WLA (cfu/day)	∑LA (cfu/day)	MOS (cfu/day)
95	241.79	7.45E+11	8.60E+10	2.24E+09	5.83E+11	7.45E+10
75	988.74	3.05E+12	8.60E+10	9.14E+09	2.65E+12	3.05E+11
50	2,985.45	9.20E+12	8.60E+10	2.76E+10	8.17E+12	9.20E+11
25	8,934.97	2.75E+13	8.60E+10	8.26E+10	2.46E+13	2.75E+12
5	27,831.37	8.58E+13	8.60E+10	2.57E+11	7.69E+13	8.58E+12

Table 14. *E. coli* TMDL and allocations for the Missouri portion of the Osage River at selected flows

Percent of time flow is equaled or exceeded	Flow ft^3/s	LC (cfu/day)	Facilities WLA (cfu/day)	MS4 WLA (cfu/day)	∑LA (cfu/day)	MOS (cfu/day)
95	114.12	3.52E+11	8.60E+10	2.24E+09	2.28E+11	3.52E+10
75	466.68	1.44E+12	8.60E+10	9.14E+09	1.20E+12	1.44E+11
50	1,409.13	4.34E+12	8.60E+10	2.76E+10	3.80E+12	4.34E+11
25	4,217.31	1.30E+13	8.60E+10	8.26E+10	1.15E+13	1.30E+12
5	13,136.40	4.05E+13	8.60E+10	2.57E+11	3.61E+13	4.05E+12

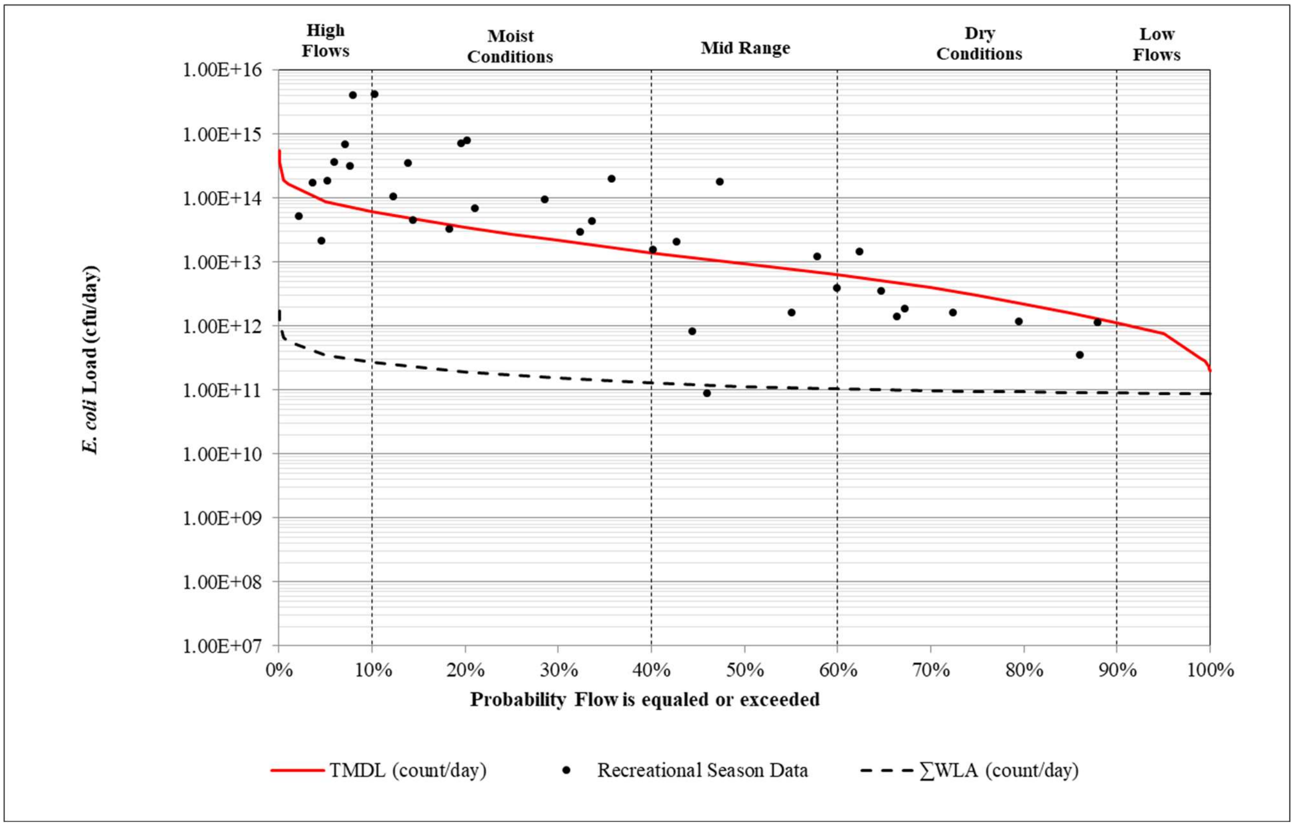

Figure 9. *E. coli* TMDL for the Osage River (WBID 1293)

8. Wasteload Allocation (Point Source Load)

The wasteload allocation is the portion of the loading capacity assigned to existing or future point sources. Pursuant to 40 CFR 122.44(d)(1)(vii)(B), effluent limits or other permit conditions must be consistent with the assumptions and requirements of TMDL wasteload allocations. Missouri cannot impose TMDL wasteload allocations onto another state, therefore, wasteload allocation targets are calculated only for Missouri permitted facilities. In order to achieve Missouri water quality standards through the loading targets established by this TMDL, it must be assumed, in accordance with federal regulation 40 CFR 131.10(b), that any point source pollutant contributions from Kansas will be limited to ensure Missouri's water quality standards will be met at the state line. The Kansas *E. coli* criterion concentration for the Osage River is 160 cfu/100mL and is less stringent than the Missouri criterion concentration of 126 cfu/100 mL.

The wasteload allocations presented in this TMDL report do not preclude the establishment of future point sources. Any future point sources should be evaluated against the TMDL, the range of flows with which any additional bacterial loading will affect, and any additional requirements associated with antidegradation. Federal regulation 40 CFR 122.4(a), disallows the issuance of a NPDES permit if the conditions of the permit cannot provide for compliance with the applicable requirements of the federal Clean Water Act, or regulations promulgated under the federal Clean Water Act. Additionally, 40 CFR 122.4(i) states no permit may be issued to a new source or new discharger if the discharge from its construction or operation will cause or contribute to violation of water quality standards. After undergoing antidegradation review, any new facility that discharges wastewater containing *E. coli* should operate in a manner that will not result in loading greater than

the established wasteload allocation. New facilities that generate *E. coli* but disinfect wastewater prior to discharge or implement other appropriate measures to eliminate *E. coli* from effluent during the recreational season (e.g., no discharge or batch discharge) will result in negligible bacteria loading and will not cause or contribute to the impairment. Decommissioning of onsite wastewater treatment systems and connecting to sewerage systems for wastewater treatment will result in net pollutant reductions that are consistent with the goals of this TMDL. Due to localized health concerns associated with bacteria and whole body contact recreation, water quality trading cannot be used as a mechanism for complying with the wasteload allocations established in this TMDL.

8.1 Domestic Wastewater Treatment Facilities

The aggregated wasteload allocations for domestic wastewater dischargers in the Osage River watershed is 8.60E+10 *E. coli* cfu/day. These allocations are based on individual facility design flows and the *E. coli* concentration target applicable to protect whole body contact recreation in the Osage River (Table 15). Actual flows that are less than the design flows may result in bacteria loads less than the calculated wasteload allocations. The wasteload allocations in this TMDL report do not authorize any facility to discharge bacteria at concentrations that exceed water quality standards, but may accommodate additional facility loading due to population increases or expansions in service area. The wasteload allocations in this TMDL report are applicable at all flows during the recreational season and do not include loading that may result from sanitary sewer overflows. Sanitary sewer overflows are unpermitted discharges and are not authorized under the Clean Water Act. For this reason, sanitary sewer overflows in the Osage River watershed are assigned wasteload allocations of zero at all flows. A zero wasteload allocation indicates a need for 100 percent reduction from contributing sources and is the most stringent wasteload allocation that can be assigned.

Table 15. Wasteload allocations for domestic wastewater discharges

Permit Number	Facility Name	*E. coli* Concentrations (cfu/100 mL)	WLA (cfu/day)
MO0109827	Emery Truck Plaza	0 (not permitted to discharge to surface waters)	0.00E+00
MO0135933	MoDNR Stockton State Park WWTF		0.00E+00
MO0134139	ADM Deerfield		0.00E+00
MO0137669	Hammons Products Company		0.00E+00
MO0023655	Drexel North WWTF		0.00E+00
MO0127540	Meadows Water Company WWTF		0.00E+00
MO0059382	USCOE Mutton Creek Marina WWTF	126	6.68E+06
MO0060089	USCOE Ruark Bluff NE PUA WWTF		7.15E+06
MO0107808	Hudson R-9 School District WWTP		1.19E+07
MO0083241	Northeast Vernon County R-1 School WWTF		1.43E+07
MO0117455	Willard Central Elementary WWTP		2.00E+07
MO0060178	USCOE Mutton Creek PUA WWTF		2.34E+07
MO0060101	USCOE Cedar Ridge WWTF		2.38E+07
MO0050172	South Park Mobile Village WWTF		2.38E+07
MO0030287	USACE Orleans Trail Park WWTF		3.58E+07
MO0112810	Calypso Cove RV Park WWTF		3.65E+07

Permit Number	Facility Name	*E. coli* Concentrations (cfu/100 mL)	WLA (cfu/day)
MO0093220	American Resort Subdivision WWTP	126	3.72E+07
MO0119628	Pleasant View Estates HOA WWTF		3.97E+07
MO0124311	Pleasant View School WWTP		4.05E+07
MO0112241	Maranatha Bible Camp WWTF		4.77E+07
MO0123277	Good Samaritan Boys Ranch WWTF		5.72E+07
MO0098191	Pilot Travel Center #385 WWTP		6.11E+07
MO0118982	Flemington WWTF		8.06E+07
MO0114715	Hume WWTF		1.07E+08
MO0103748	Rockville WWTP		1.19E+08
MO0120472	Bronaugh WWTF		1.26E+08
MO0125091	Amsterdam WWTF		1.34E+08
MO0127680	Agape Boarding School WWTP		1.43E+08
MO0128767	Amoret WWTF		1.43E+08
MO0103756	Collins WWTF		1.65E+08
MO0103942	Walker WWTF		1.92E+08
MO0118320	Everton WWTF		2.29E+08
MO0129747	South Greenfield WWTP		3.03E+08
MO0040177	Sheldon WWTF		3.39E+08
MO0107174	Walnut Grove WWTP		3.62E+08
MO0113514	Fair Play WWTF		4.10E+08
MO0037052	Camp Clark Training Site WWTF		4.77E+08
MO0045837	Liberal WWTF		4.77E+08
MO0052281	Willows Utility Company WWTP		4.77E+08
MO0055603	Greenfield Talburt WWTF		5.63E+08
MO0042480	Billings WWTP		5.77E+08
MO0055590	Greenfield Sharpe WWTF		6.11E+08
MO0025739	Humansville WWTF		7.67E+08
MO0030473	Lockwood WWTF		1.14E+09
MO0092517	Rich Hill WWTF		1.39E+09
MO0023205	Ash Grove WWTP		1.59E+09
MO0055280	Stockton WWTP		1.91E+09
MO0021105	Appleton City WWTF		3.72E+09
MO0040002	El Dorado Springs WWTP		4.53E+09
MO0096229	Butler WWTP		7.15E+09
MO0089109	Nevada WWTP		9.54E+09
MO0022098	Republic WWTP		1.53E+10
MO0103039	Springfield NW WWTP		3.24E+10
		Total	**8.60E+10**

8.2 Industrial and Commercial Facilities

There are twelve facilities in the Osage River Watershed that hold general permits for industrial processes that could potentially generate *E. coli* (Section 5.1.2). Six of these facilities are permitted for land application or subsurface dispersal of meat processing wastewater. There are two facilities that hold general permits for land application of domestic waste. There are three facilities that hold general permits for land application of food processing wastewater. One facility holds a general permit for land application of animal compost wastewater. These facilities are not authorized to discharge to surface waters and, as long as the requirements of the relevant subdivisions of the permits are met, will not contribute *E. coli* to the Osage River watershed. Because these facilities are prohibited from discharging to surface waters, the wasteload allocation for these twelve facilities is zero at all flows. There are three site-specific permitted industrial or commercial facilities in the Osage River watershed. These facilities do not actively generate *E. coli* and are not expected to cause or contribute to the *E. coli* impairment of Osage River. For this reason, the wasteload allocation for these facilities is set at existing loading based on current permit limits and conditions, which is expected to be negligible and not exceed the sum of the total wasteload allocation.

8.3 Concentrated Animal Feeding Operations

The CAFO facilities in the Osage River watershed are subject to permit conditions that do not allow discharge directly or during land application. For this reason, the *E. coli* wasteload allocations for the CAFO facilities is zero at all flows. A wasteload allocation of zero is the most stringent allocation that can be assigned and indicates the need for 100 percent pollutant reduction from any contributing sources.

8.4 Municipal Separate Storm Sewer Systems

Potential load contributions for MS4s were calculated based on the relative area of the watershed contained within MS4 systems. Areas potentially draining to MS4s account for approximately 24 square miles, or 0.3 percent of the entire Osage River watershed. The aggregated wasteload allocation for MS4s varies with stream flow and was calculated by multiplying the total loading capacity for the Osage River watershed by the relative area within the watershed that contributes to a MS4 system. Due to the relatively small percentage of area potentially contributing runoff to regulated MS4 systems, no pollutant reductions from existing MS4s are expected to meet the assigned wasteload allocations. Continued implementation of existing permit requirements to reduce pollutant loading to the maximum extent practicable is expected to meet the assumptions and requirements of the TMDL wasteload allocation. If the area contributing to the MS4s expands or additional MS4 permits are required for stormwater discharges from other developed areas in the future, then the appropriate proportion of the load allocation, as it relates to stormwater pollutant contributions, may be re-assigned as a wasteload allocation without revision to this TMDL.

8.5 Other General Permitted Wastewater and Stormwater Discharges

Activities associated with other general or stormwater permits described in Section 5.1.5 are not typically expected to contribute *E. coli* to surface waters, and permit conditions are protective of the designated uses assigned to all water bodies in the watersheds. Activities for which these permits are issued are expected to be conducted in compliance with all permit conditions, including any land application, monitoring, stormwater pollution prevention plans, and discharge limitations. For these reasons, the *E. coli* wasteload allocations for these facilities are set at current negligible

loading based on existing permit limits and conditions. Future general and stormwater permitted activities that do not actively generate bacteria and that operate in full compliance with permit conditions are not expected to contribute bacteria loads above negligible levels and will not result in loading that exceeds the sum of the TMDL wasteload allocations.

8.6 Illicit Straight Pipe Discharges

Illicit straight pipe discharges are illegal and are not permitted under the federal Clean Water Act. For this reason, illicit straight pipe discharges are not allocated a portion of the available loading capacity and are assigned an *E. coli* wasteload allocation of zero. Any existing illicit straight pipe discharges must be eliminated and future discharges of this type should be prevented. Illicit discharge detection and elimination is a required permit condition in areas having a regulated MS4.

9. Load Allocation (Nonpoint Source Load)

The load allocation is the portion of the loading capacity assigned to existing and future nonpoint sources and natural background contributions (40 CFR 130.2(g)). The load allocation for this TMDL is calculated as the remainder of the loading capacity after allocations to the wasteload allocation and the margin of safety, as presented in Section 7. The load allocations include contributions from agricultural lands, runoff from developed areas, and natural background contributions. No portion of the load allocations is assigned to onsite wastewater treatment systems because when they are properly maintained and operating as designed they do not discharge *E. coli* directly to surface waters. For this TMDL, the load allocation also includes any point source and nonpoint source contributions originating from Kansas. Despite Kansas' *E. coli* criterion concentration for the Osage River of 160 cfu/100mL, it is assumed, in accordance with federal regulation 40 CFR 131.10(b), that point source contributions from Kansas will be limited to ensure Missouri water quality standards are met at the state line.

10. Margin of Safety

A margin of safety is required to account for uncertainties in scientific and technical understanding of water quality in natural systems (CWA Section 303(d)(l)(C) and 40 CFR 130.7(c)(l)). Based on EPA guidance, the margin of safety can be achieved through two approaches:

- Explicit - Reserve a portion of the loading capacity as a separate term in the TMDL.
- Implicit - Incorporate the margin of safety within the wasteload allocation and the load allocation calculations by making conservative assumptions in the analysis.

For this TMDL both implicit and explicit margins of safety are used. At low flows (greater than or equal to 99 percent flow exceedance) only an implicit margin of safety is applied. At all other flow conditions, in addition to implicit margins of safety, an explicit margin of safety equal to 10 percent of the loading capacity is also applied. Bacteria decay rates were not applied, and the direct recreational-season geometric mean concentration was applied as a target for estimating daily loading value as required by the federal Clean Water Act. Additionally, domestic wastewater treatment facilities employing disinfection technologies operate to eliminate nearly all present pathogens rather than targeting a specific water quality criterion (target = 0 cfu/day). This results in pollutant loading much lower than assigned wasteload allocations. These conservative assumptions serve as implicit margins of safety and are applicable during all flow conditions.

It should also be noted that Missouri's recreational bacteria criteria, and targets used in this TMDL, do not differentiate between human and nonhuman sources of *E. coli*. Technical support materials published by EPA in 2024 and a quantitative microbial risk assessment published by EPA in 2010 note decreased risk of illness associated with recreational uses in waters where *E. coli* contamination occurs from nonhuman sources, such as livestock, manure, or wildlife (USEPA 2024 and USEPA 2010). In some instances, risks of illness from recreational exposure were described as being 20 to 30 times less in animal-impacted waters than human-impacted waters (USEPA 2010). Although conservative assumptions incorporated into water quality criteria are not implicit margins of safety as it pertains to TMDLs, such information lends support that TMDL targets will be greatly protective of recreational uses in largely forested or agriculturally dominated subwatersheds of the Osage River where human inputs are less likely or significantly less than animal sources.

Through the department's assessment methodologies and approach for development of this TMDL, effort was made to reduce overall uncertainty in the analyses. A majority of the *E. coli* samples collected over the last ten years were analyzed using an enzyme-specific media (Idexx/Colilert method). This method helps reduce variability, thus resulting in a more accurate and higher *E. coli* yield as compared to if conventional culture media are used. Finally, when calculating the load duration curves, the department used verified measured flow data from USGS gage stations. Together these quality assured data were used to provide estimates of existing loading from which pollutant reduction targets can be derived.

Due to reduced uncertainty in the analysis and calculation of loading targets, along with the various implicit margins of safety outlined above, the department feels the approach used to calculate this TMDL appropriately includes an adequate and sufficient margin of safety to fulfill the requirements of 40 CFR 130.7(c)(1). The use of an additional explicit margin of safety of 10 percent is intended to account for other unspecified and unquantified uncertainties or unknowns. Reserving a portion of the available loading capacity and not allocating it to either point or nonpoint sources only further ensures that water quality standards will be achieved when all wasteload and load allocations are achieved.

11. Seasonal Variation

Federal regulations at 40 CFR 130.7(c)(1) require that TMDLs take into consideration seasonal variation in applicable water quality standards. The load duration curve provides the *E. coli* loading capacities for the Osage River at all possible flow regimes using data collected during all seasons. The *E. coli* TMDL is therefore protective of designated recreational uses during critical conditions throughout the recreational season, including during high flows associated with intense rainfall events when bacteria loading is more likely.

12. Monitoring Plans

The department conducts water quality monitoring in impaired waters within a reasonable timeframe following the approval of TMDLs, completion of facility upgrades and permit compliance schedules, or the implementation of watershed BMPs. The department will also routinely examine any available quality-assured water quality data collected by other local, state, and federal entities in order to assess the effectiveness of TMDL implementation. In addition, certain quality-assured data collected by universities, municipalities, private companies, and volunteer groups may be used to assess water quality following TMDL implementation.

13. Reasonable Assurance

Section 303(d)(1)(C) of the federal Clean Water Act requires that TMDLs be established at a level necessary to implement applicable water quality standards. As part of the TMDL process, consideration must be given to the assurances that point and nonpoint source allocations will be achieved and water quality standards attained. Where TMDLs are developed for waters impaired by point sources only, reasonable assurance is provided through the NPDES permitting program. Missouri state operating permits requiring effluent limits and monitoring provide reasonable assurance that instream water quality standards will be met.

Where a TMDL is developed for waters impaired by both point and nonpoint sources, point source wasteload allocations must be stringent enough so that in conjunction with the water body's other loadings (i.e., nonpoint sources) water quality standards are met. Reasonable assurance that nonpoint sources will meet their allocated amount is dependent upon the availability and implementation of nonpoint source pollutant reduction plans, controls, or BMPs within the watershed. If BMPs or other nonpoint source pollution controls allow for more stringent load allocations, then wasteload allocations can be less stringent. Thus, the TMDL process provides for nonpoint source control tradeoffs (40 CFR 130.2(i)). When a demonstration of nonpoint source reasonable assurance is developed for an impaired water body, additional pollutant allocations for point sources may be allowed provided water quality standards are still attained. If a demonstration of nonpoint source reasonable assurance does not exist, or it is determined that nonpoint source pollutant reduction plans, controls, or BMPs are not feasible, durable, or will not result in the required load reductions, then allocation of greater pollutant loading to point sources cannot occur.

A variety of grants and loans may be available to assist watershed stakeholders with developing and implementing watershed based plans, controls, and practices to meet the required wasteload and load allocations in the TMDL and demonstrate reasonable assurance. Information regarding potential funding sources, cost-share opportunities, and implementation actions that address nonpoint source loading in the Osage River watershed are provided in the supplemental TMDL Implementation Strategies document available online at: dnr.mo.gov/water/what-were-doing/water-planning/quality-standards-impaired-waters-total-maximum-daily-loads/tmdls.

14. Public Participation

EPA regulations at 40 CFR 130.7 require that TMDLs be subject to public review. An extended 76-day public notice period for this TMDL report was scheduled from December 22, 2023, through March 7, 2024. Groups that directly received notice of the public comment period for this TMDL include, but are not limited to:

- Missouri Clean Water Commission;
- Kansas Department of Health and Environment;
- Missouri Department of Conservation;
- Mo-Kan Regional Planning Commission;
- Northwest Missouri Regional Planning Commission;
- County Soil and Water Conservation Districts;
- County health departments;
- County commissions;
- University of Missouri Extension;

- Missouri Coalition for the Environment;
- Missouri Farm Bureau;
- Stream Teams United;
- Stream Team volunteers living in or near the watershed;
- Affected permitted entities; and
- Missouri state legislators representing areas within the watershed.

In addition to those groups directly contacted about the public notice, this TMDL report and an implementation strategies document are posted on the department's TMDL webpage at: dnr.mo.gov/water/what-were-doing/water-planning/quality-standards-impaired-waters-total-maximum-daily-loads/tmdls.

The department maintains an email distribution list for notifying subscribers of significant TMDL updates or activities, including public notices and comment periods. Those interested in subscribing to TMDL updates can submit their email address using the online form available at public.govdelivery.com/accounts/MODNR/subscriber/new?topic_id=MODNR_177.

15. Administrative Record and Supporting Documentation

The department has an administrative record on file for the Osage River *E. coli* TMDL. The record contains information on which the TMDL is based. It additionally includes the TMDL implementation strategies document, the public notice announcement, any public comments received, and the Department's responses to those comments. This information is available upon request to the Department at: dnr.mo.gov/open-records-sunshine-law-requests. The department will process any request for information about this TMDL in accordance with Missouri's Sunshine Law (Chapter 610, RSMo) and the department's administrative policies and procedures governing Sunshine Law requests.

16. References

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Appendix A

Table A-1. Available *E. coli* data for recreational season for the Osage River (1293)

Year	Site Code	Site Name	*E. coli* (cfu/100ml)
2014	1293/23.2	Osage R. ab. Schell City	210.00
2014	1293/23.2	Osage R. ab. Schell City	50.00
2014	1293/23.2	Osage R. ab. Schell City	85.00
2014	1293/23.2	Osage R. ab. Schell City	1,500.00
2014	1293/23.2	Osage R. ab. Schell City	7,400.00
2015	1293/23.2	Osage R. ab. Schell City	2,900.00
2015	1293/23.2	Osage R. ab. Schell City	1,200.00
2015	1293/23.2	Osage R. ab. Schell City	560.00
2015	1293/23.2	Osage R. ab. Schell City	280.00
2015	1293/23.2	Osage R. ab. Schell City	30.00
2016	1293/23.2	Osage R. ab. Schell City	1.00
2016	1293/23.2	Osage R. ab. Schell City	900.00
2016	1293/23.2	Osage R. ab. Schell City	110.00
2016	1293/23.2	Osage R. ab. Schell City	500.00
2016	1293/23.2	Osage R. ab. Schell City	64.00
2017	1293/23.2	Osage R. ab. Schell City	2,500.00
2017	1293/23.2	Osage R. ab. Schell City	50.00
2017	1293/23.2	Osage R. ab. Schell City	260.00
2017	1293/23.2	Osage R. ab. Schell City	27.00
2017	1293/23.2	Osage R. ab. Schell City	8,700.00
2018	1293/23.2	Osage R. ab. Schell City	9.00
2018	1293/23.2	Osage R. ab. Schell City	230.00
2018	1293/23.2	Osage R. ab. Schell City	320.00
2018	1293/23.2	Osage R. ab. Schell City	36.00
2018	1293/23.2	Osage R. ab. Schell City	57.00
2018	1293/23.2	Osage R. ab. Schell City	300.00
2018	1293/23.2	Osage R. ab. Schell City	190.00
2019	1293/23.2	Osage R. ab. Schell City	250.00
2019	1293/23.2	Osage R. ab. Schell City	220.00
2019	1293/23.2	Osage R. ab. Schell City	30.00
2019	1293/23.2	Osage R. ab. Schell City	120.00
2019	1293/23.2	Osage R. ab. Schell City	2,200.00
2020	1293/23.2	Osage R. ab. Schell City	580.00
2020	1293/23.2	Osage R. ab. Schell City	140.00
2020	1293/23.2	Osage R. ab. Schell City	77.00
2020	1293/23.2	Osage R. ab. Schell City	110.00

Appendix B

Development of *E. coli* Load Duration Curves

Overview

A load duration curve was used to develop the *E. coli* TMDL for the Osage River. Load duration curves visually display the loading capacity of a water body at all possible flows based on historical flow data and the defined target concentration for each pollutant. For this TMDL, a portion of the *E. coli* loading capacity is assigned to a wasteload allocation based on the individual design flows of domestic wastewater treatment facilities present in the watershed and the relative watershed area that contributes to MS4s. Ten percent of the loading capacity is reserved as an explicit margin of safety except for the lowest one percent of flow conditions, where only an implicit margin of safety is applied. The remaining portion of the loading capacity is allocated to nonpoint sources.

Methodology

Load duration curves are based on flow duration curves developed using a long-term time series of daily flows and a numeric water quality target. Average daily flow data that are representative of the impaired segment are used to develop the flow duration curve. If sufficient flow records for the impaired stream segment are not available, then flow data collected from a gage in a representative watershed may be used, or a flow duration curve can be derived by synthesizing long-term flow data from several gages within the same ecological drainage unit.

For the western portion of the Osage River watershed excluding the Sac River watershed, flow estimates were area-corrected based on flows measured at USGS stream gage 06918070, located on the Osage River above Schell City from May 1981 to February 2012, and USGS stream gage 06918250, located on the Osage River near Taberville, from Februrary 2012 to December 2020. Average daily flows were corrected based on the proportion of the area draining to the impaired water body segment for each respective gage. For the Sac River Watershed, which is contained within the eastern portion of the Osage River watershed, flow estimates were area-corrected based on flows measured at USGS stream gage 06919900, located on the Sac River near Caplinger mills from May 1981 to December 2020. The flow duration curve for the entire Osage River watershed was developing using the combined area-corrected flow estimates from the western portion of the Osage River watershed and the Sac River watershed. Table B-1 presents the area correction factors and Figure B-1 presents the flow duration curve developed for the impaired segment.

The loading capacity was derived using the applicable Missouri water quality criterion, which is more conservative than the Kansas water quality criterion. The loading capacity was calculated based on the Missouri whole body contact category A *E. coli* criterion concentration of 126 cfu/100 mL, average daily flows, and a conversion factor of 24,465,715 in order to generate the loading capacity in units of cfu/day.[23]

[23] $Load\left(\frac{\text{count}}{\text{day}}\right) = \left[Target\left(\frac{\text{count}}{\text{100ml}}\right)\right] * \left[Flow\left(\frac{feet^3}{s}\right)\right] * [Conversion\ Factor]$

Table B-1. Information used for developing area corrected flow records[24]

Watershed	Gage Drainage Area (mi^2)	Watershed Area (mi^2)	Conversion Factor
USGS 06918250 Osage River at Taberville, MO	5,670	6,215 (Osage River Watershed)	1.096
USGS 06918070 Osage River above Schell City, MO	5,410	6,215 (Osage River Watershed)	1.149
USGS 06919900 Sac River near Caplinger Mills, MO	1,810	1,969 (Sac River Watershed)	1.088

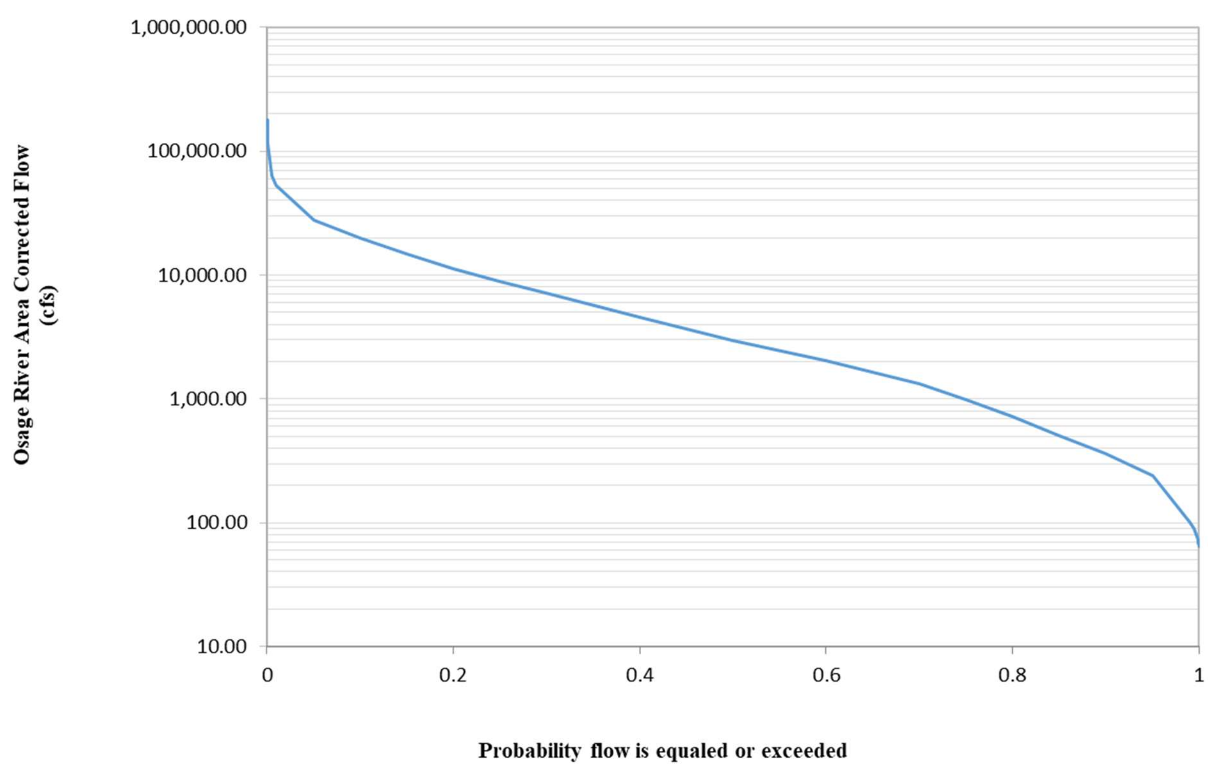

Figure B-1. Osage River Flow Duration Curve

[24] Flow data that were in provisional status at the time of this report were not used.